US Army Corps
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Waterways Experiment
Station

Final Report
CPAR-CHL-97-2
September 1997

CONSTRUCTION PRODUCTIVITY ADVANCEMENT RESEARCH (CPAR) PROGRAM

Development of a Portable Innovative Contaminated Sediment Dredge

by

Trimbak M. Parchure, Charles N. Sturdivant

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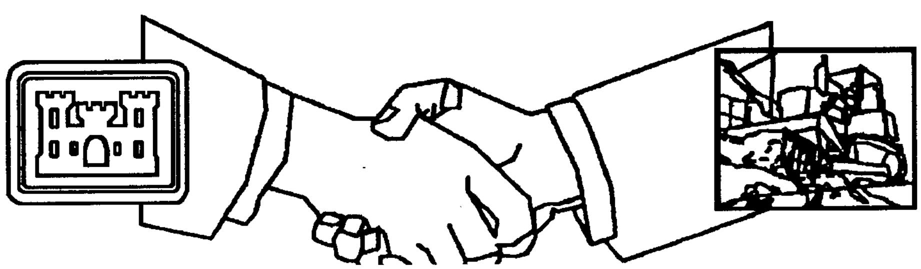

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A Corps/Industry Partnership to Advance Construction Productivity and Reduce Costs

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Construction Productivity Advancement Research (CPAR) Program

Technical Report
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Development of a Portable Innovative Contaminated Sediment Dredge

by Trimbak M. Parchure

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Charles N. Sturdivant

DRE Technologies
137 Alpha Drive
Franklin, TN 37064

Final report

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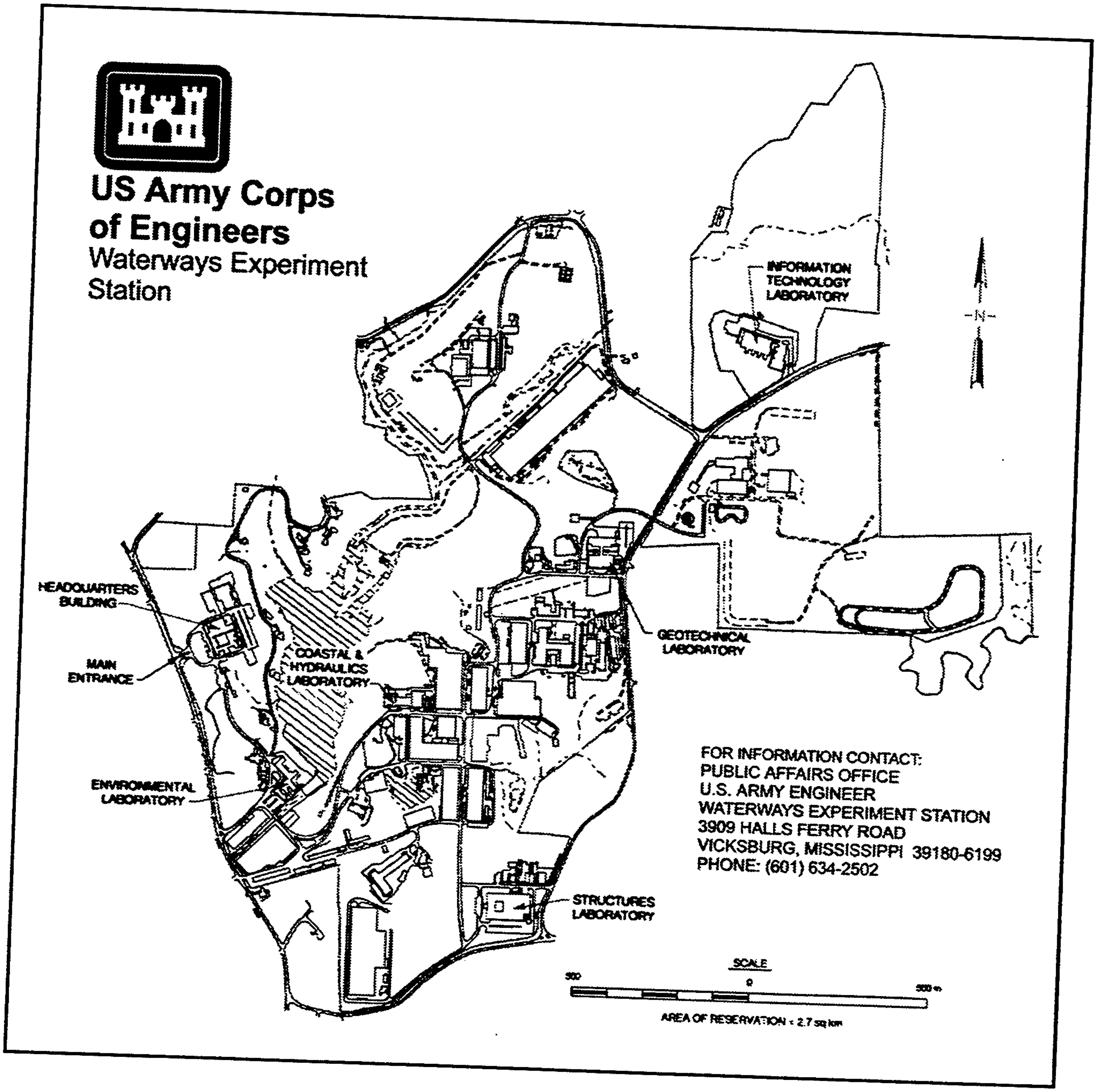

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Preface

Section 7 of the Water Resources Development Act of 1988, P. L. 100-676, 33, U.S.C. 2313, and the Stevenson-Wydler Technology Innovation Act of 1980, as amended, 15 U.S.C. 37102a, provide the legislative authority for the Construction Productivity Advancement Research (CPAR) Program. The CPAR Program allows the U.S. Army Corps of Engineers (USACE) to enter into cooperative research and development agreements with construction industry partners to conduct cost-shared, collaborative efforts with the goal of improving construction productivity.

Memorandum CEWES-OC-Z was issued on 23 February 1995 enclosing copies of the Cooperative Research and Development Agreement (CRDA) document which was jointly signed by U.S. Army Engineer Waterways Experiment Station (WES) and DRE Technologies Inc. This memorandum conveyed approval of the Director of Civil Works for WES to enter into CPAR CRDA wth DRE Technologies Inc. for "Development of a Portable Innovative Contaminated Sediment Dredge."

The research work was conducted by personnel of DRE Technologies Inc. and the WES Coastal and Hydraulics Laboratory (CHL), Vicksburg, MS, during 1995 - 1996. Funding for this project ($675,000) was received from the Government under the CPAR Program and an amount of $855,000 was contributed by DRE Technologies Inc.

Dr. Trimbak M. Parchure, Waterways and Estuaries Division, CHL, was the Principal Investigator for the project and Mr. Charles Sturdivant of DRE Technologies Inc. was the Principal Investigator of the partner. Dr. Parchure prepared this report jointly with Mr. Sturdivant. Dr. Parchure conducted the project work under the general supervision of Messrs Allen M. Teeter, Leader, Sedimentation Engineering and Dredging Group; William H. McAnally, Jr., Chief, Waterways and Estuaries Division; Richard A. Sager, Assistant Director, CHL; and Dr. James R. Houston, Director, CHL. William F. McCleese of WES monitored the progress of the project, provided advice, and maintained constant liaison with Headquarters, USACE. The USACE Technical Monitor was Mr. Tom Verna.

This report is being published by the WES Coastal and Hydraulics Laboratory (CHL). The CHL was formed in October 1996 with the merger of the WES Coastal Engineering Research Center and Hydraulics Laboratory. Dr. James Houston is the Director of the CHL, and Messrs Richard A. Sager and Charles Calhoun, Jr. are Assistant Directors.

During the preparation and publication of this report, Dr. Robert W. Whalin was the Director of WES.

Acknowledgments

The joint CPAR project between DRE and the U. S. Army Corps of Engineers on the Development of a Portable Innovative Contaminated Sediment Dredge officially started in February 1995 after both parties signed the CPAR-CRDA. The groundwork, however, had started in 1994. The project continued for a period of two years and was completed in December 1996.

Successful completion of this project was possible only because of the excellent cooperation and participation of personnel from both sides. In particular, appreciation is expressed to the following individuals and companies:

a. DRE contractors Automated Equipment Inc., located in Paris, TN, completed the initial fabrication of the dredge on time for undertaking the lake dredging project at WES. They also made several modifications to the dredge after the first field trial.

b. Mr. Glynn Banks was the key person at WES during the entire field trial of lake dredging. He offered advice on availability of labor, materials, repair facilities, and renting services from the local market in Vicksburg and Jackson, MS. He provided several valuable suggestions for making modifications to enhance efficiency of the dredge during actual operation.

c. The initial dredge design was done by Mr. Charles Sturdivant of DRE. He was involved with the project from the very beginning and was also responsible for monitoring dredge performance and for making subsequent modifications.

d. Ms. Rachelle Green prepared and published an article on the field trial of Dry DREdge™.

e. Participation and assistance from the following DRE personnel is appreciated:

(1) Mr. James Harlan for conducting the pump tests.

(2) Mr. Samuel Escue for numerous engineering support activities.

(3) Mr. Kerth Northrop for supervising the field testing at WES.

(4) Mr. Mark Frazier for supervising the field testing at Louisville, KY.

1 Project Background

Introduction

A survey of portable hydraulic dredges was undertaken at the U. S. Army Engineer Waterways Experiment Station (WES) in the years 1981-1982. A report entitled "Survey of Portable Hydraulic Dredges" was published by Clark (1983) on the findings of the survey, which was limited only to the U.S. market. This report summarized a wide variety of portable dredges available in the United States. It was revealed that the dredging depths ranged from 3.048 to 18.3 m (10 to 60 ft) and production rates ranged from 15.3 to over 1,376.2 cu m (20 to over 1,800 cu yd) per hour. The cutting mechanisms included ordinary cutterheads, ladders with chain cutters, bucket wheels, horizontal cutters, twin rotating vertical cutters, open suction dustpans, and jet pumps. The degree of portability varied considerably. Individual descriptions and a summary chart for each dredger are given in Clark (1983).

Ten years after the above report, another survey on portable dredgers was conducted by WES (during 1993) and a report entitled "Equipment for Contaminated Sediment Dredging" published by Parchure (1996). This survey was restricted to only the equipment available in the U.S. market suitable for contaminated sediment dredging. In all, 64 companies related to dredge manufacture were contacted. Out of these, information on their respective products was received from 24 companies. A careful scrutiny of the information revealed that only 7 companies offered equipment which appeared promising for contaminated sediment dredging.

Considerable emphasis has been being placed in recent years on the toxic contents of sediment to be removed from our waterways. Special attention and technology are mandated by regulations if the sediments to be removed are contaminated. According to an estimate given in the Office of Technology Assessment document O-334, entitled "Wastes in marine environment," (Clark 1987) approximately 3 percent of the material dredged from the estuaries and coastal areas each year in the United States is heavily contaminated. The cost of removing, transporting, and disposing this material is three to six times as much as noncontaminated material.

Three major problems are associated with dredging contaminated sediments. First, contaminated sediments are mostly fine (consisting of silt and clays) and may be highly compacted. Specialized devices are needed for cutting and loosening them before transporting. The second problem is the ease with which dredged fine sediments are vertically resuspended and dispersed within the entire water column. A few grams of fine sediment may contain millions of particles in the micron-size range, and they attenuate penetration of natural light in the water column, thus adversely affecting the aquatic plants and water quality. The third problem is the extremely low rate of deposition of fine sediments and the ease at which they may be transported over great distances from the point of origin even under a very weak current.

Innovative equipment developed through a cooperative research project is described in this report. This equipment is expected to allow the Corps of Engineers and others to remove contaminated material from our nation's waterways and from water bodies located on military reservations with minimal impact on the environment. The dredging and disposal costs are expected to be 40 to 70 percent lower than that with the use of presently employed conventional dredgers. The main advantage of the new system is the reduced overall volume of sediments and water to be handled and treated. In addition, precise dredging will be useful in closely following the predetermined limits of contaminated sediments and also in avoiding unexploded ordnance at certain sites. The equipment is portable and small in size. Hence, it can be easily transported and deployed at small projects such as dredging of marinas and industrial lagoons where access near piles and other structures inside basins is severely restricted.

DRE Technologies Inc.

DRE Technologies Inc., located near Nashville, TN, has been providing specialized pollution control services since 1987. Specific services have included engineering, construction, start-up, permitting, and operation of facilities involved in the destruction and/or treatment of hazardous waste and wastewater, surface and subsurface investigations, remedial action, and waste minimization. The various types of services offered by the company include design services, operational services, remediation services, and regulatory assistance services.

DRE's interest in dredging technology began in the early 1990s. The company was seeking an economical and environmentally acceptable method to excavate, dewater, and feed contaminants to treatment systems at remedial action sites. The conventional methods of hydraulic and mechanical dredging had severe limitations for this type of work. The company was interested in undertaking a project for developing new technology that would be most suitable for the job and requested assistance from WES to provide research support.

Collaborative Research Program

Successful negotiations were held between WES and DRE Technologies Inc. in 1994 on the possibility of working together for the development of a portable innovative dredge for removal of contaminated sediments. Funding for the joint project was provided by the Government's share of the Construction Productivity Advancement Research (CPAR) Program.

The project objective was to develop and demonstrate a new concept for dredging contaminated sediments. The product will be a commercially available portable dredge capable of accurately removing and transferring subaqueous material near in situ densities while minimizing resuspension of contaminated solids.

The document "Research, Development and Commercialization Plan" (RDCP) was prepared which contained project description, tasks to be performed by both parties, and a schedule in the form of milestones. The document was signed by DRE and WES in February 1995. Appendix A gives the CPAR Executive Summary.

Research and Development Investment

The total research and development (R&D) cost of the project was $1,550,000, with each partner contributing funds over a 2-year period as indicated below. On this CPAR project, no funds were provided to DRE directly by the Government. Contribution of DRE was $200,000 more than the Government contribution.

Partner	Year 1	Year 2	Total
DRE	$ 750,000	$125,000	$ 875,000
Corps	$ 330,000	$345,000	$ 675,000
Total	$1,080,000	$470,000	$1,550,000

Approach

The development of the dredge included design, fabrication, and testing. The design was produced by DRE; fabrication was done by a sub-contractor; and WES helped in conducting laboratory and field testing. The following approach was envisaged for development:

Phase 1: The validity of the fundamental premise upon which this project was based will be established in this phase - namely that a high pressure positive displacement pump is capable of pumping dredged sediment at near in situ moisture content. This concept had not been demonstrated either by the dredging industry or by the pump industry.

Phase 2: Detailed design and construction of the dredge will be accomplished in this phase. The design will include a sealed clamshell mounted on a rigid telescopic boom. This configuration will permit accurate control on location and in situ hydraulic closure as well as filling of clamshell, thus reducing resuspension of bed sediment normally associated with the impact of a free-falling, cable-suspended clamshell.

Phase 3: Testing of the prototype dredge at two field dredging sites will be done during this phase. During the tests, changes in the suspended sediment concentration of ambient water will be measured, and data related to production rate and performance of the dredge will be collected and analyzed. A videotape will be made for technical and commercial distribution.

The purpose of the proposed research was to provide the construction industry with improved capability for removing contaminated sediments and to reduce the volume of material to be transported and disposed. Material removed with the proposed equipment will have close to in situ water content which may be on the order of 20 percent as opposed to the current hydraulic dredging practices which add about 200 to 400 percent volume as water.

The Dry DREdge™

The new dredge developed under the CPAR Project has been designed as a general purpose, easy-to-use tool and is now readily available in the market. The dredge is intended for use in environmental, industrial, and municipal projects. The new concept may be considered to be hybrid since the design offers advantages of both the mechanical and hydraulic dredge. The objective of the design was to provide a commercially available portable dredge capable of accurately removing and transferring subaqueous material at near in situ densities while minimizing resuspension of contaminated solids. The new dredger is named Dry DREdge™ in view of the low water content of the dredged sediment. It has received U. S. Patent No. 5,311,682.

A schematic drawing of the Dry DREdge™ is given in Figure 1. The dredge has a specially designed sealed clamshell mounted on a rigid, extensible boom. The open clamshell is hydraulically driven into the sediments at a low speed, minimizing sediment disturbance and resuspension. The clamshell is then hydraulically closed and sealed, trapping a plug of sediment at its in situ water content. The sediment is deposited in the hopper of a positive displacement pump which delivers it through a pipeline to the disposal site. Depending on the site conditions, the hopper can be equipped for debris screening, size reduction,

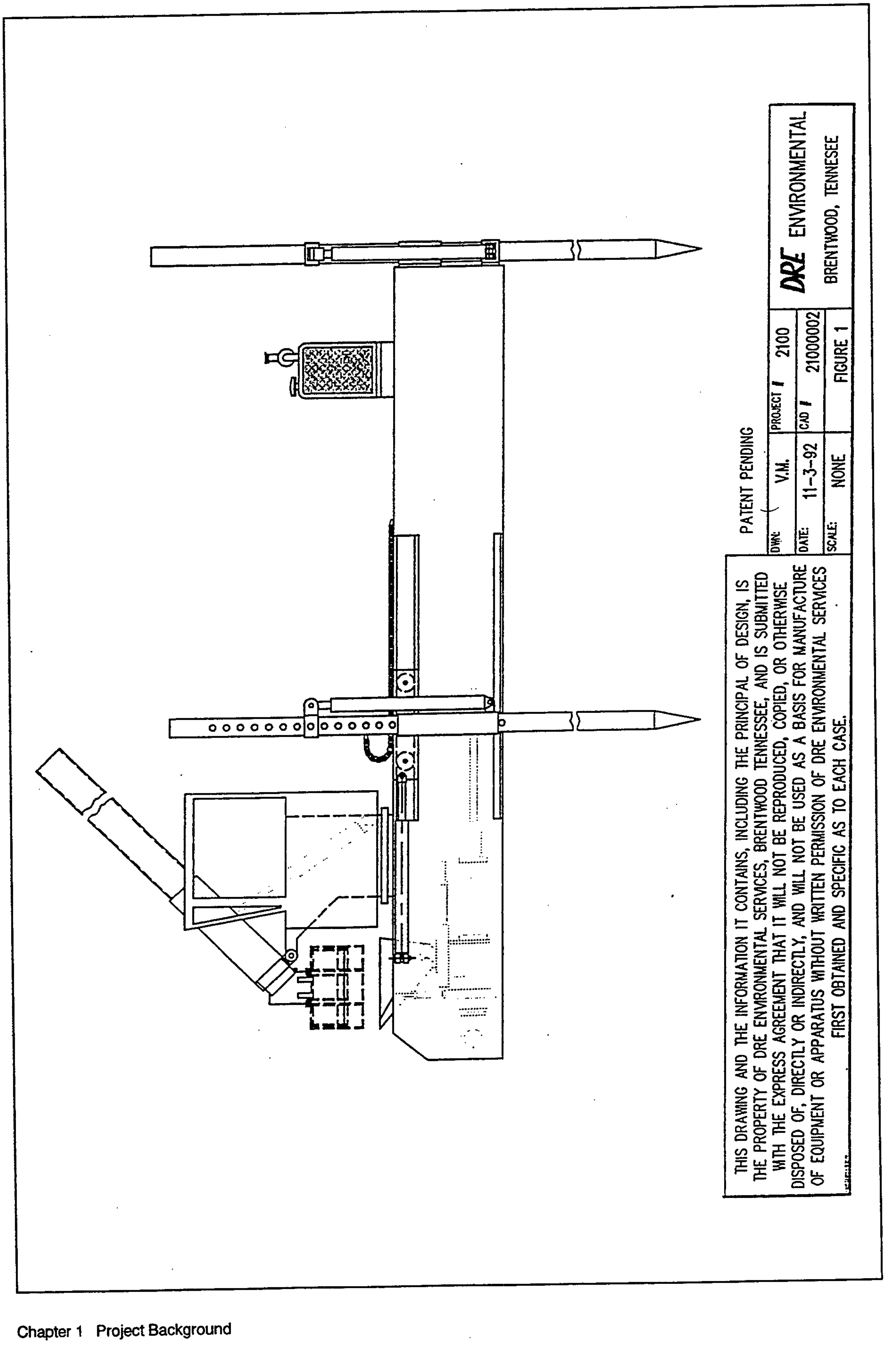

Figure 1. Schematic drawing of DRY DREdge™

vapor emission control, sediment homogenization, and blending of additives to modify flow properties. The sediment pumped in a plastic flow regime may have the consistency of a toothpaste. Depending on the in situ moisture content and the degree of hazard posed by the sediment, the disposition may be directed to a thermal treatment or stabilization process, to an onsite land disposal, or to an enclosed transport vehicle.

The dredge is portable and therefore capable of being transported by road without major disassembly. Only one truck is required to transport Dry DREdge™, and the setup requires a crane and approximately 16 man hours. Larger units suitable for operation in coastal environments require three or four trucks and approximately 80 man hours of setup labor.

Extensive special training is not needed to operate Dry DREdge™ since it can be operated by an experienced dredge/backhoe/clamshell or dragline operator. However, a deckhand is required to assist the operator in handling the pipe and to perform normal maintenance duties. The new dredge is expected to have a service life in excess of 15 years if regular maintenance is performed. No major modifications are necessary to meet customer-specific requirements.

The design employs technologies well-proven in other industries. The primary task in the development of this dredge was the integration of these technologies into a reliable piece of equipment.

Impact On U. S. Industry

The new dredge should satisfy a need in the dredging industry: a machine capable of excavating and transporting sediments without the addition of large amounts of water. This feature will allow dredging of areas that cannot presently be dredged due to the nonavailability of a large and suitable containment area for pumping slurry for gravitational settling. Small jobs, such as dredging of marinas and private boat docks, will no longer require the construction of large sedimentation basins and return water systems. Due to the reduced amounts of water, the dredge discharge can be directed into much smaller geographic depressions or cells constructed for that purpose.

The environmental remediation business will be favorably affected by the introduction of the new dredge. With the Dry DREdge™, sediment dredging projects can be performed without the expense of dewatering and treating large amounts of water. Also, direct pumping to prepared disposal and draining areas can be considered instead of using expensive treatment systems.

For those projects where the material to be removed is first transformed into slurry for ease of pumping and the slurry is then mechanically dewatered (primarily environmental projects), the new design will offer an option which will greatly reduce the cost of dewatering and water treatment.

Additionally, the new design overcomes a common problem plaguing small dredges used to feed dewatering equipment, namely, frequent shutdown from pipe blockage due to debris. The hybrid dredge operation is largely unimpeded by debris since the sediment is screened and readily visible to the operator for manual removal of debris, if needed, before it enters the pump.

Impact On Corps of Engineers

The impact on the U.S. Army Corps of Engineers will be the following:

a. The dredge will be capable of precise, low impact excavation. This feature is useful when the cut lines are precisely defined, as in many Comprehensive Environmental Responsibility Compensation and Liability Act (CERCLA) (Superfund) projects, which must be adhered to because there may be a risk of encountering unexploded ordnance (UXO) beyond these lines.

b. The dredge will be very useful for small dredging projects of the Corps of Engineers, particularly those which involve excavation and treatment of contaminated sediments.

c. With the new dredge, the dewatering and water treatment costs will be substantially reduced as will the exposure of personnel to the contaminants.

d. The portable dredge will be useful for inland dredging sites such as lakes and ponds.

e. The dredge will be useful for the dredging of commercial marinas and private boat docks.

f. The new dredge will eliminate or greatly reduce the return water from the disposal cell used for a conventional hydraulic dredge. This will, in turn, eliminate or reduce the adverse environmental impact from the return water.

2 Design and Fabrication

Design

The new dredge design was required to overcome the disadvantages of conventional dredges deployed for removal of contaminated sediments. These disadvantages are as follows:

a. Resuspension of sediment at the point of excavation is often significant, and it may adversely affect the quality of water.

b. Excavation of "hot spots" may not be precise.

c. A large quantity of water is required to be mixed with the sediment in order to make it flow properly through a pipe when a centrifugal pump is used.

d. High water content of the dredged sediment requires large, expensive confined areas for disposal and settlement of sediment.

e. When the sediments are contaminated, return water from confined areas is also polluted, and its discharge back into the same body of water may not be permitted.

f. High water content of polluted sediment dramatically increases the cost of incineration since substantial energy is wasted in evaporating large quantities of water.

The main component of the new dredge is the positive displacement pump. DRE contacted and negotiated with five pump manufacturers. DRE also surveyed all known pipe-coupling manufacturers and compiled information on all options for steel and plastic pipes available in the market. The hull of the dredge was not to be designed to make it a sea-worthy dredger. The new dredge was designed only for inland and protected areas where wave action is not a matter of concern. A joint meeting of WES and DRE officials was held at WES on 24 March 1995 to discuss details of the project. Research facilities existing at WES were inspected to determine their suitability for pump testing.

The design of the clamshell offers several noteworthy features. The clamshell can be extended from the surface of the water through layers of water or sediment to the desired depth of sediment to be removed. The clamshell (0.1982 cu m (7 cu ft) volumetric capacity) can then be closed, sealing sediment inside the clam. This prevents the sediment from leaking out or being diluted by infiltrating water or other sediment layers while the clam is raised to the water surface.

The system for positioning the clamshell on the sediment bed and providing feedback to the dredge operator consists of electronic sensors, a computer, and a digital display inside the operator's cabin. This display indicates the extension of the boom, the clam position or offset to either side of the dredge center line, and the depth of the clam below the water surface. This system allows the operator to consistently dredge at a predetermined depth and not leave undredged areas.

For small projects such as the dredging of marinas and industrial inland lagoons, elaborate on-line data acquisition systems are not necessary. Nuclear density meters are available for determining the density of sediment flowing through a pipe. A comprehensive global positioning system (GPS) is available in the market for accurate positioning of a dredger in open water sites. Also available in the market is elaborate and expensive software, such as HYPAC©, that provides on-line data on depth of dredging and computation of volume of dredged material among many other features which require an on-board computer. If needed, such accessory facilities can be installed for operation in a large area.

DRE first prepared the manpower allocation schedule for the design phase and employed qualified personnel for the job. Clamshell design and spud system design were completed by September 1995, and the entire design job was completed by November 1995, thus meeting Milestone 2 one month ahead of schedule.

Fabrication

The contract for fabrication of the dredge was given to Automated Equipment Inc., Paris, TN. The work was completed by mid-April 1996, two months ahead of schedule.

Preliminary Testing

Preliminary testing of the engine, pump, and other parts was done at the shop at Automated Equipment Inc. The dredge was then taken to a nearby pond to test its dredging ability. Both these preliminary tests were completed satisfactorily, thus making the dredge ready for a field test.

3 Laboratory Tests at WES

Introduction

Research work under the CPAR Program was conducted at WES. It was used to ascertain the validity of the fundamental premise upon which this project is based, namely, that a high-pressure positive displacement pump is capable of pumping dredged sediments at near in situ moisture contents. Additionally, this research was used to measure and compare the hydraulic characteristics of steel and polyethylene pipe in service with various types of sediment. These data were crucial to the successful design of the dredge. From the initial inquiries, DRE ascertained that none of the pump manufacturers had conducted tests on different types of pipe, nor had they collected necessary data. Detailed design and construction of the dredge was finalized only after the results of the pump and pipeline testing program were analyzed and the viability of the concept was affirmed.

Procurements

A concrete mixer, a piston-type concrete pump, a scissors-lift-type elevating platform, a flash mixer, and an air compressor were rented by DRE for operation at WES. Three types of sediments (kaolinite, bentonite, and sand) and a storage tank were purchased by WES. Steel pipes, plastic pipes, flexible hoses, lumber, valves, couplings, and pressure meters were purchased by DRE.

Planning and Design

DRE performed pressure, flow, and velocity calculations in support of the pipe selected for testing. Based on the information related to equipment and materials available in the market, a testing plan was developed. In consultations with WES, a layout drawing showing a 12.7-cm- (5-in.-) by 274.32-m- (900-ft-) long steel pipeline, couplings, pressure gauges, pump, and other technical details was prepared for use in construction of the testing facility.

Research Facility Construction

An experimental facility (Figures 2-13) was constructed at WES for conducting tests for pumping mud through the pipeline in accordance with drawings prepared by DRE. The steel pipeline was laid on the ground for a length of 137 m (450 ft) going away from the pump and another 137 m (450 ft) returning towards the pump for recirculating the mud through the pipe. The farther ends of pipe were connected by a U-piece. A piston-type concrete pump was used for the tests. The pipes were connected to each other by victaulic couplings and were supported on lumber blocks . They were connected to the concrete pump by flexible hoses, and pressure gauges were installed at pre-determined locations. Construction was complete by 9 June 1995.

Sediment Characterization

Instead of using natural sediment for conducting laboratory pumping tests at WES, it was decided to use sediment mixtures constituted in the laboratory. Such mixtures were favored because they are pollution-free and have defined and consistent physical properties. The cohesive sediments selected were the clay minerals kaolinite and bentonite which are commercially available. The noncohesive sediment was ordinary construction sand. Size distribution is shown in Figure 14.

Samples of wet sediment in water were initially prepared in the WES laboratory for kaolinite and bentonite clays alone, and the bulk densities of mixtures were measured. The results are given in Tables 1 and 2.

Several additional samples were then prepared by combining different percentages of kaolinite/bentonite and kaolinite/bentonite/sand. The ratio of sediment mixture to water was maintained at 1:3 for all, and the bulk density of each sample was determined. The results are given in Table 3.

The objective of preparing these laboratory samples was to create workable mixtures with a high sediment content and low water content, resulting in a high bulk density. No specific indices or criteria exist for a formal characterization of such samples to describe the ease with which the sediments can be pumped through a pipe. Rheological properties of a sediment-water mixture are important in addition to the physical properties while considering their ease of pumping through pipes. Specific samples which had the best potential of pumping through the positive displacement pump were selected for conducting the actual tests. The conclusions from laboratory characterization of sediment mixtures were:

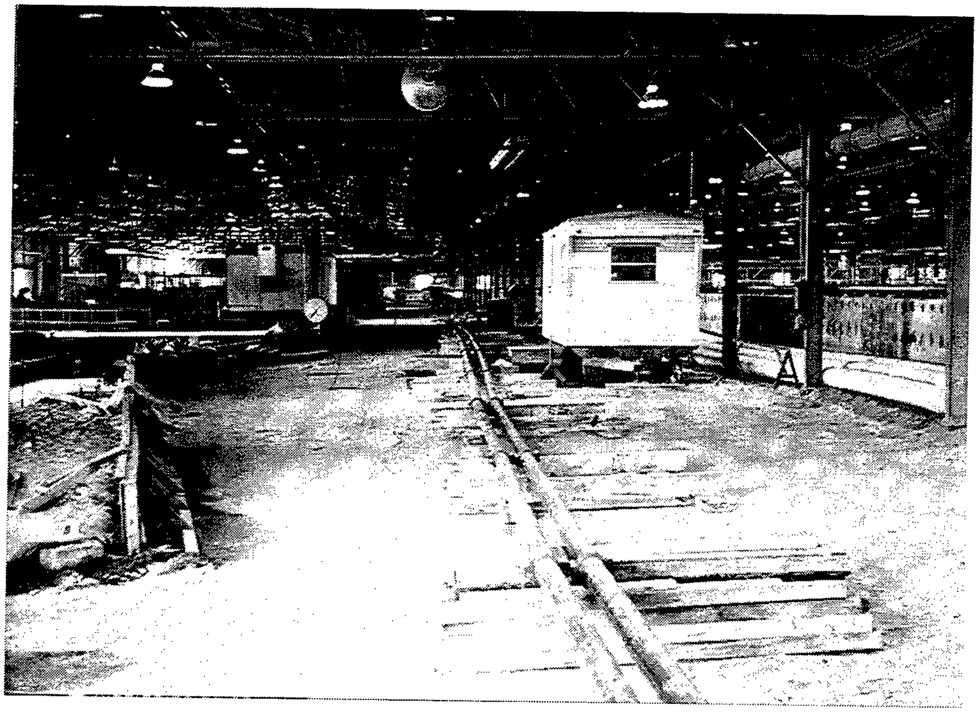

Figure 2. View of pipelines inside the test facility at WES

a. Stiffness of sediment mixture increased with a higher percentage of bentonite.

b. The bulk density of sediment mixture increased rapidly with the addition of sand.

c. For the same ratio of sediment to water, bentonite has lower bulk density than kaolinite because of its swelling property.

d. Kaolinite mixtures are easy to pour, whereas, for the same relative quantity of water, bentonite forms a gel at low water content, and the container must be squeezed to expel the mixture.

Pump and Pipeline Tests

The two parameters measured during tests were the rate of pumping and the pipe pressure. The types of pump, pipeline, and coupling were selected based on pump and pumpline testing. The variables considered in the pump selection included the operating pressure range, the type of valve (slide/swing), the number of valves (one/two), and the number of cylinders (one/two).

Pipeline considerations included material of construction (steel/polyethylene), size and wall thickness, and type of connectors (groove/flanged/welded/flexible).

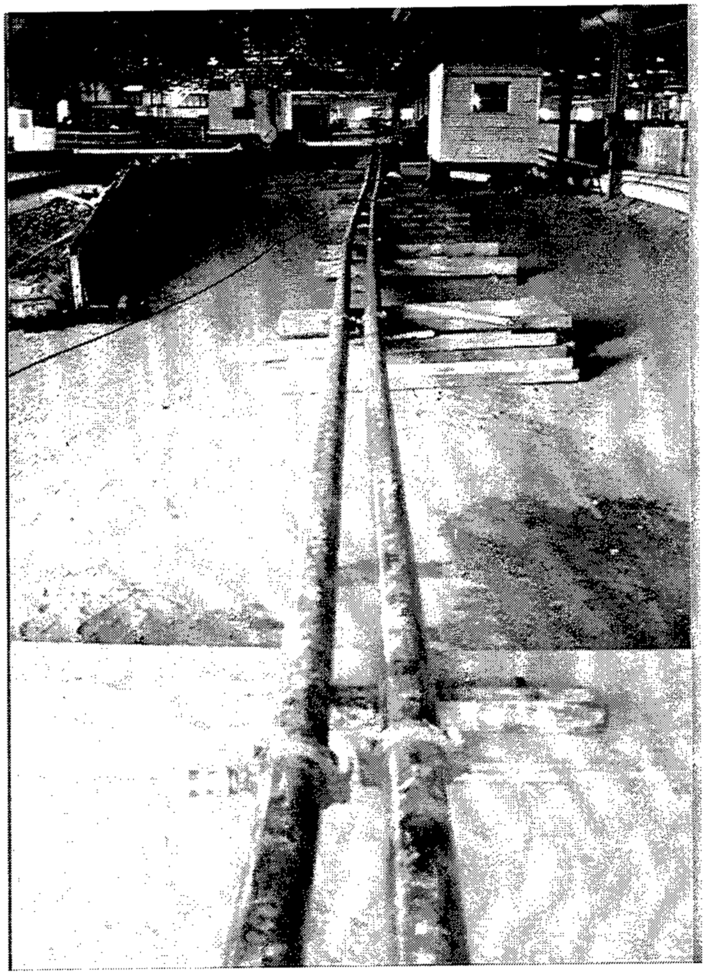

Figure 3. Recirculating pipes

The operating variables included a matrix of pressure, velocity, and horsepower with varying types of sediments.

A series of tests was conducted for different combinations of the following parameters: type of sediment (kaolinite, bentonite, and sand), amount of water, type of pipe material (steel and plastic), and pipe diameter (127 mm (5 in.) and 144 mm (6 in.)). Pressure was measured at the beginning of the pipe, at the U-loop, and at halfway along the straight reach.

Sediments were weighed on a scale and the weight of water was determined from its volume. For instance, under the test KS1, there were 2,041 kg (4,500 lb) of kaolinite, 2,041 kg (4,500 lb) of sand, and 4,082 kg (9000 lb) of water in the concrete mixer, giving a proportion of 1:1:2. The relative proportions (by weight) of different constituents of sediment-water mixture used in the tests were:

Figure 4. Kaolinite and bentonite in bags

Test 1: (K1) Kaolinite + water at 1:3, Bulk density = 1.18 g/cm^3

Test 2: (K2) Kaolinite + water at 1:2.5, Bulk density = 1.23 g/cm^3

Test 3: (K3) Kaolinite + water at 1:1, Bulk density = 1.45 g/cm^3

Test 4: (KS1) Kaolinite + sand + water at 1:1:2, Bulk density = 1.53 g/cm^3 (This had 50 percent of sediment in the mixture by weight.)

Test 5: (KS2) Kaolinite + sand + water at 1:2:2, Bulk density = 1.56 g/cm^3 (This had 60 percent of sediment in the mixture by weight.)

Test 6: (KS3) Kaolinite + sand + water at 1:2:2, Bulk density = 1.75 g/cm^3 (This had 74 percent of sediment in the mixture by weight.)

Test 7: (KS4) Kaolinite + sand + water at 1:2:2, Bulk density = 1.95 g/cm^3 (This was too thick and dry to pump. Hence, an extra 10 percent of the quantity of water already existing in the mixture was added, and then the mixture could be pumped.)

Test 8: (B1) Bentonite + water at 1 : 8, Bulk density = 1.11 g/cm^3

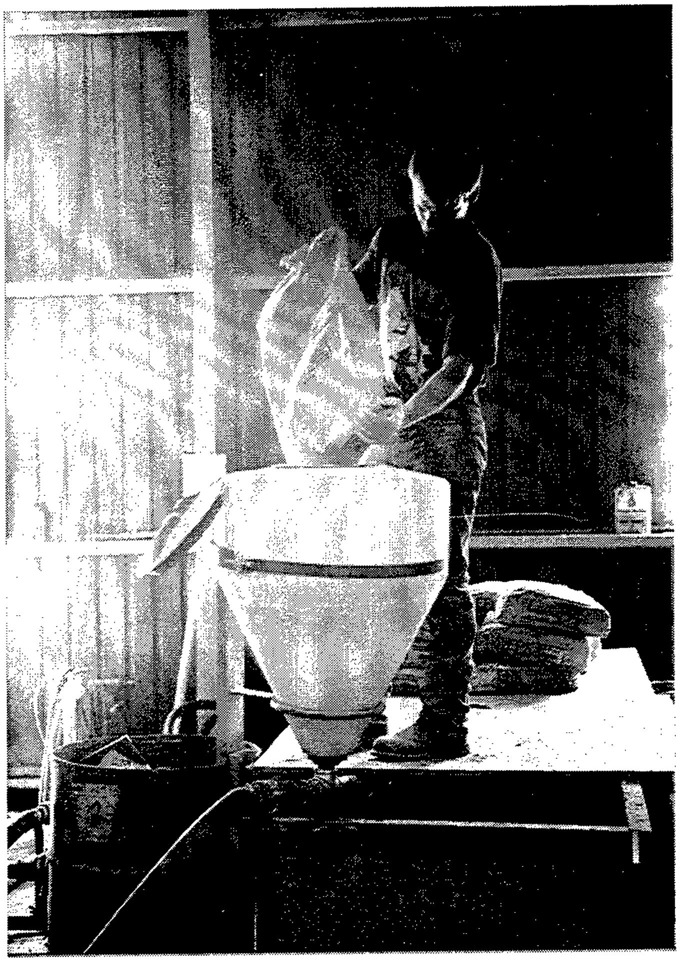

Figure 5. Flash mixer used for initial mixing of sediment and water

Test 9: (BK1) Bentonite + kaolinite + water at 1 : 1 : 9, Bulk density = 1.11 g/cm^3

Test 10: (BKS1) Bentonite + kaolinite + sand at 75/15/10 percent, Sediment/water = 1/3

Test 11: (BKS2) Bentonite + kaolinite + sand at 64/21/15 percent, Sediment/water = 1/3

Test 12: (BKS3) Bentonite + kaolinite + sand at 60/40/20 percent, Sediment/water = 1/3

All of the above sediments could be successfully pumped through the 127-mm- (5-in.-) diam steel pipeline during laboratory tests.

The conclusions of the laboratory tests were:

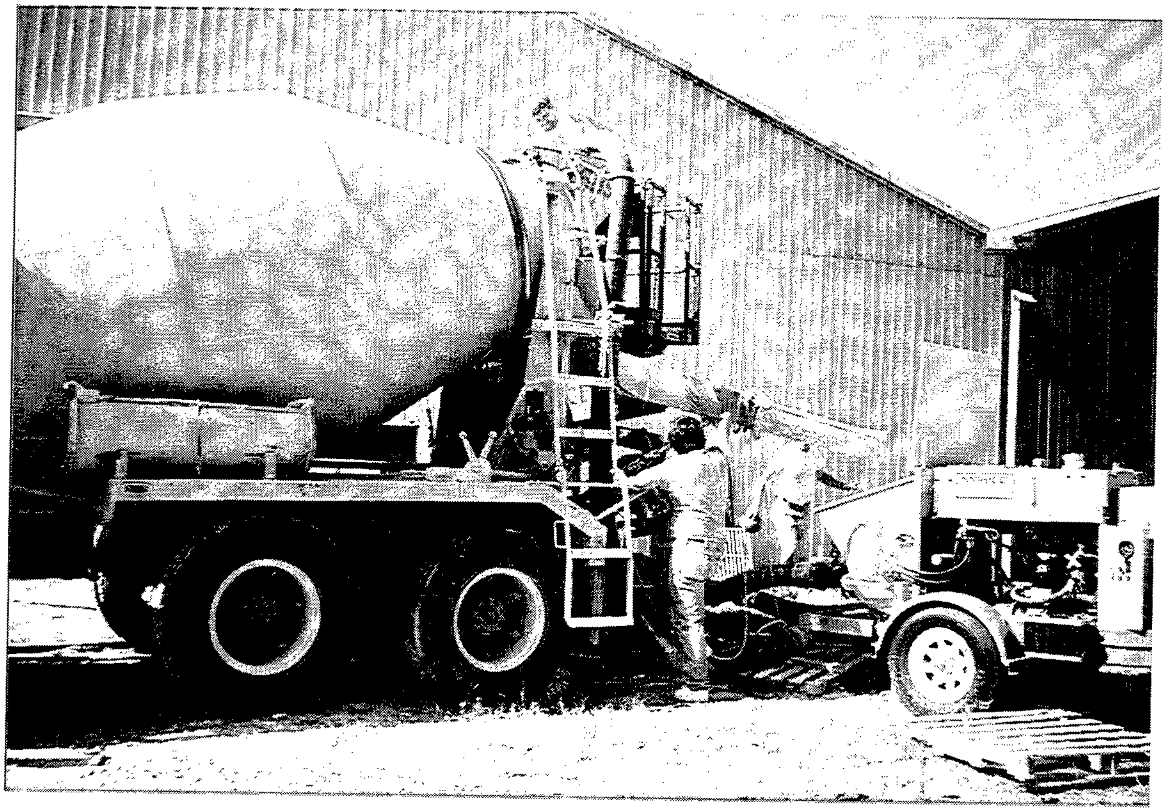

Figure 6. View of concrete mixer used for mixing sediment and water

a. Variation in the pipe pressure as a function of sediment parameters was not very great.

b. The pressures ranged between 3.447 and 4.48 MPa (500 and 650 psi) against the design pressure of 6.894 MPa (1,000 psi). Pressure was generally inversely proportionate to water content.

c. The output of sediment was on the order of 23 to 30 cu m (30 to 40 cu yd) per hour.

d. It was possible to pump sediments with specific gravity as high as 1.75.

e. The positive displacement pump was effective in pumping mixtures with a large percentage of sediment (clay and sand) and a low water content.

f. The pipeline choked when an attempt was made to pump a mixture of kaolinite + sand + water with ratios of 1:2:2. However, this mixture was pumpable after the water content was increased by 10 percent.

g. Clays acted as a lubricant and made pumping of sand easier when the clay percentage increased. This also reduced the total head loss in a pipe during pumping.

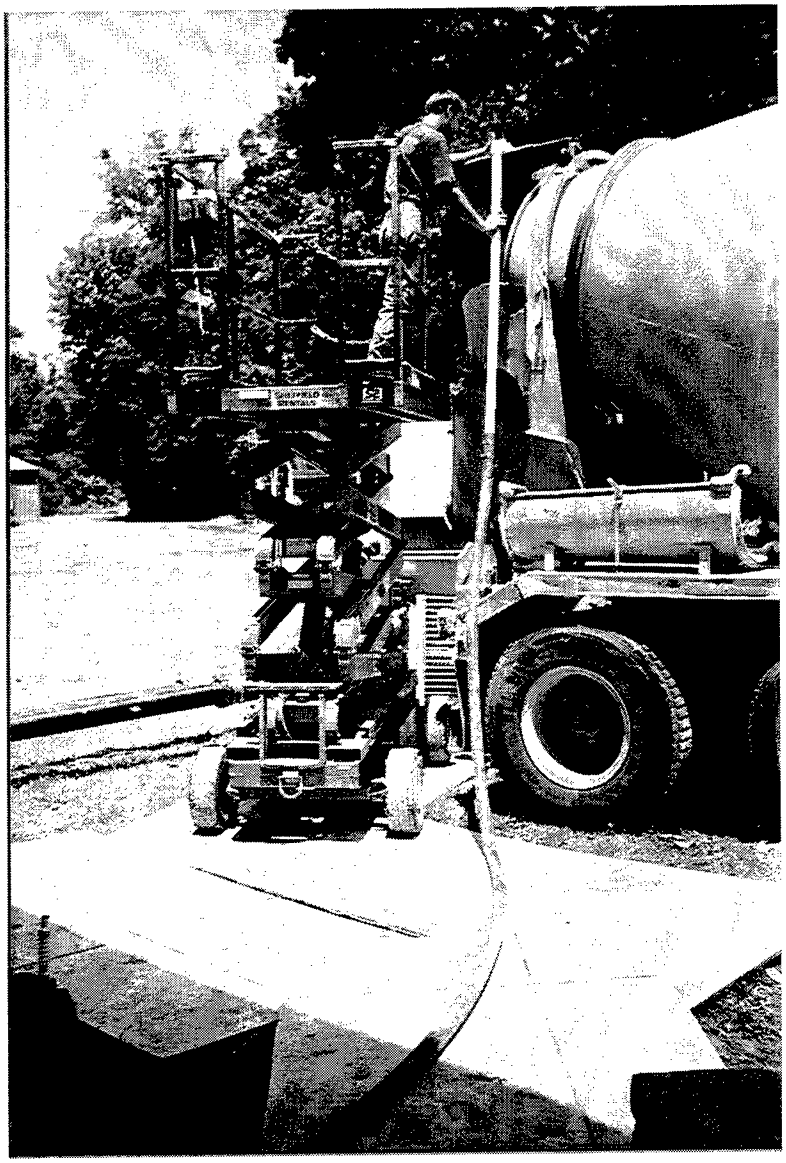

Figure 7. View of scissors-lift-type elevating platform

The Vice President and Principal Engineer of DRE visited WES on 29 June 1995 to witness and discuss the pump tests. All the tests were completed by August 1995, thus providing timely input for the dredge design.

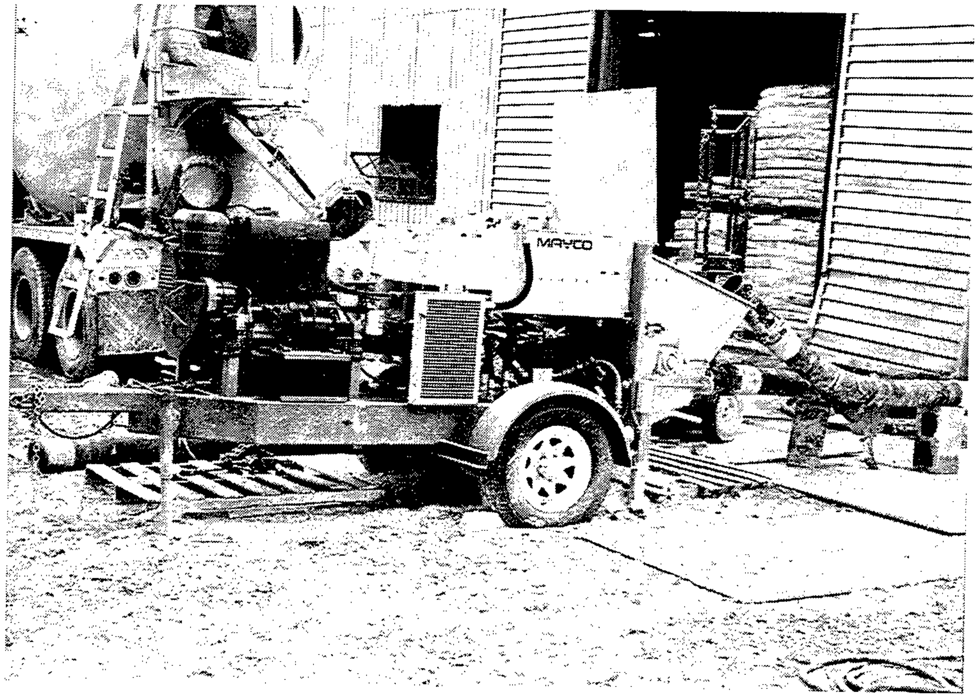

Figure 8. View of reciprocating two-cylinder pump used for pumping mud

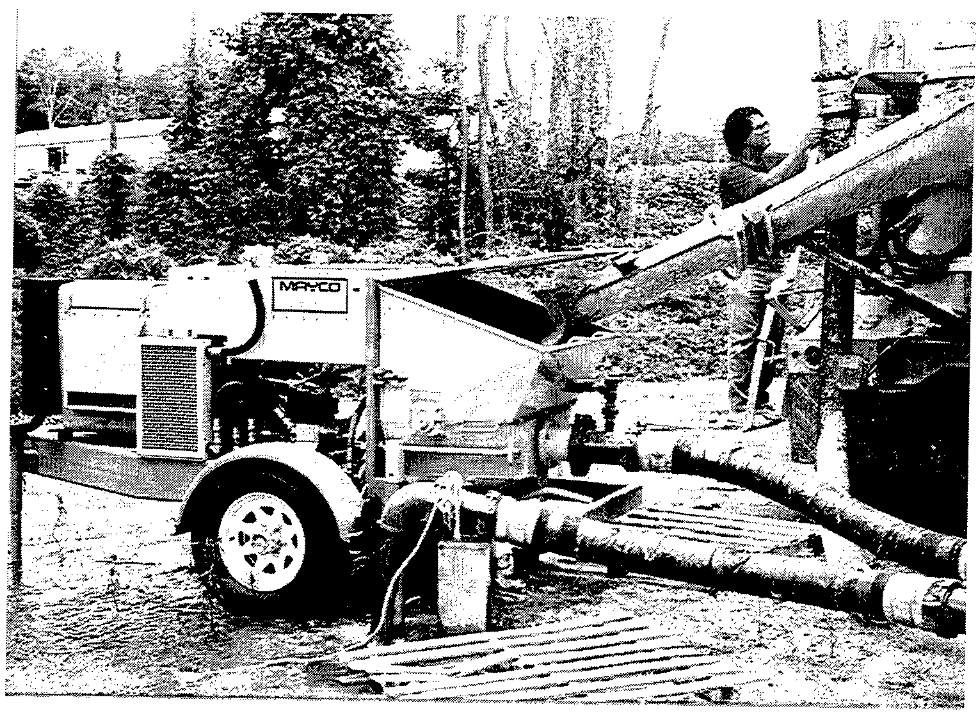

Figure 9. View of hopper attached to pump for temporary storage of sediment

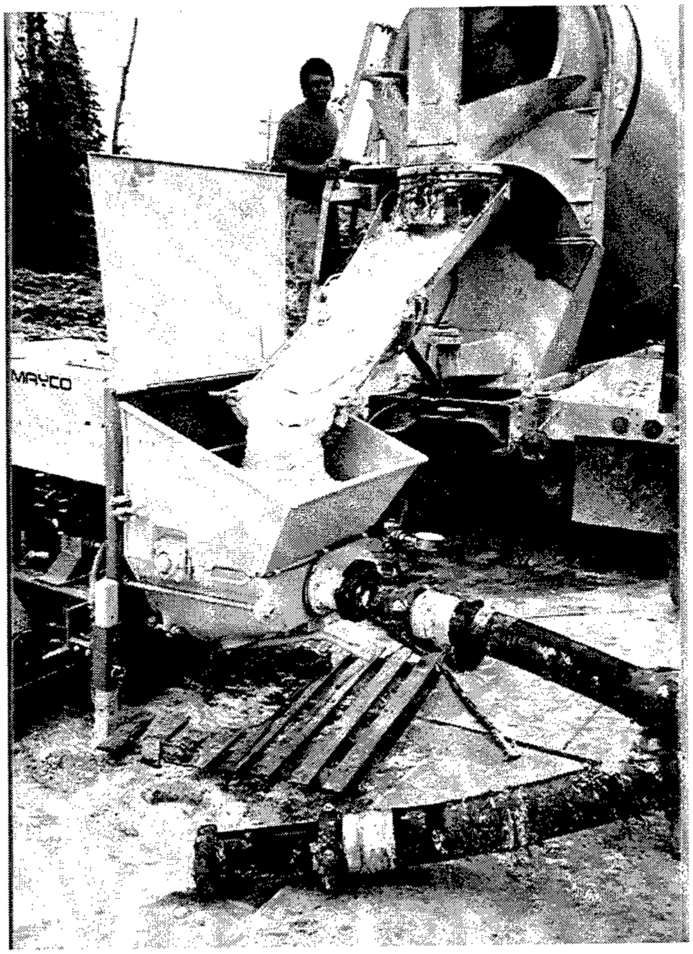

Figure 10. Mixture of sediment and water poured in pump hopper

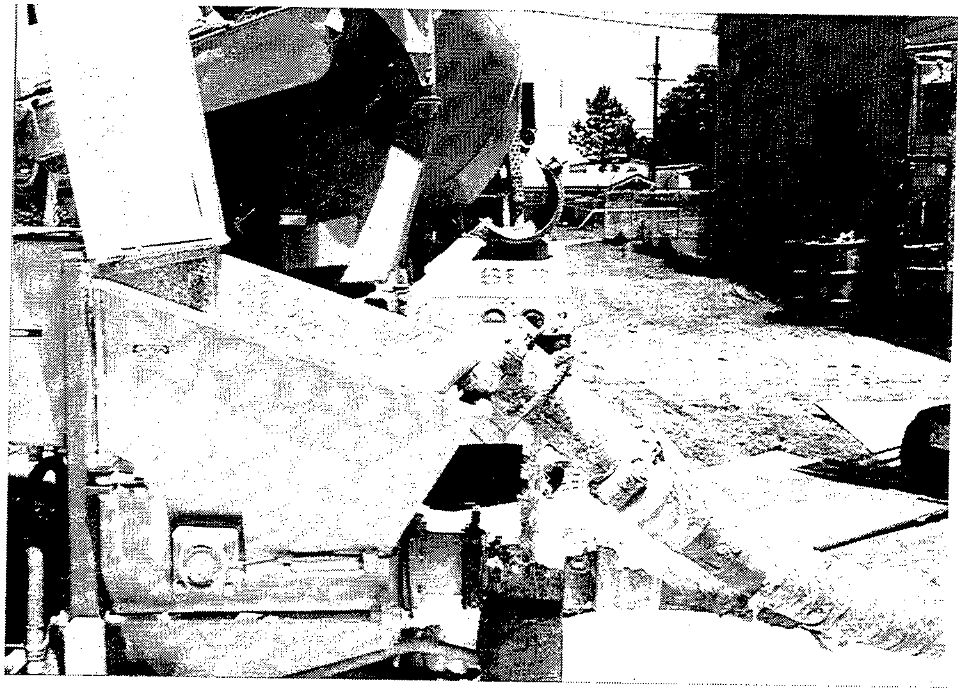

Figure 11. Mixture of sediment and water returning to the hopper after flow through pipe

Figure 12. Pressure gauges installed at the bend on pipeline

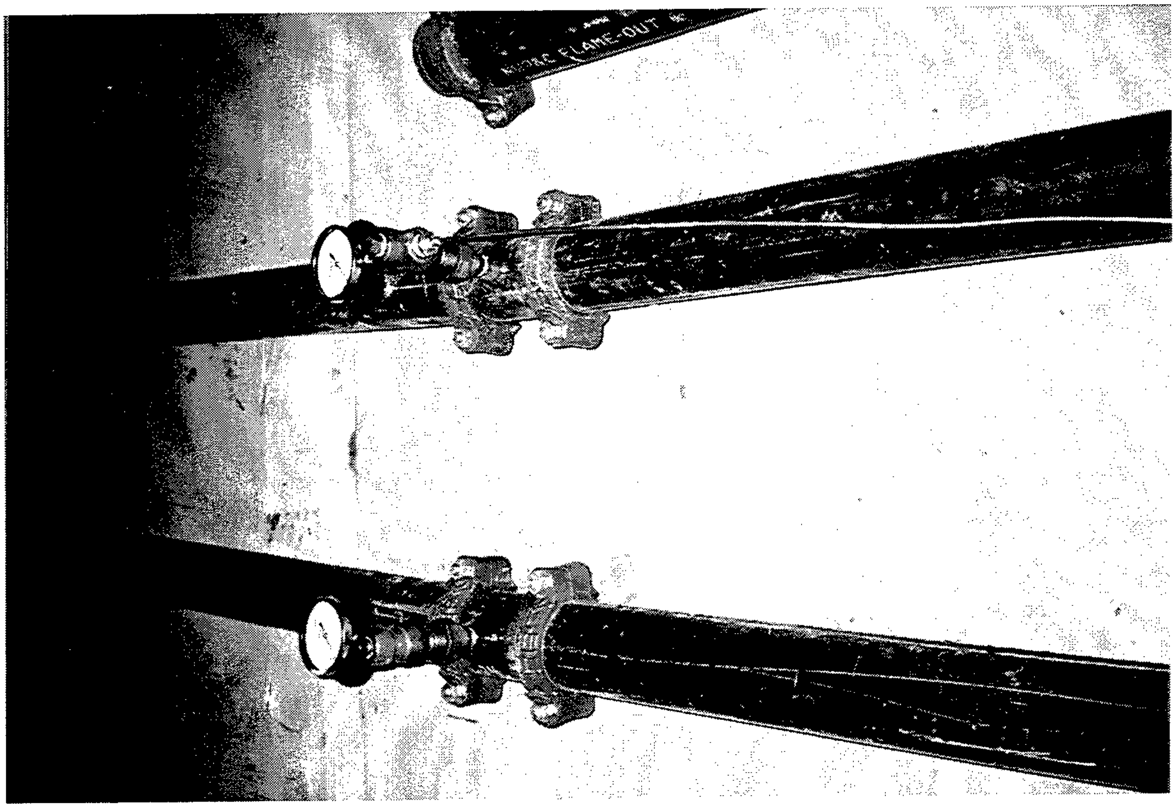

Figure 13. Pressure gauges installed halfway on the two pipes

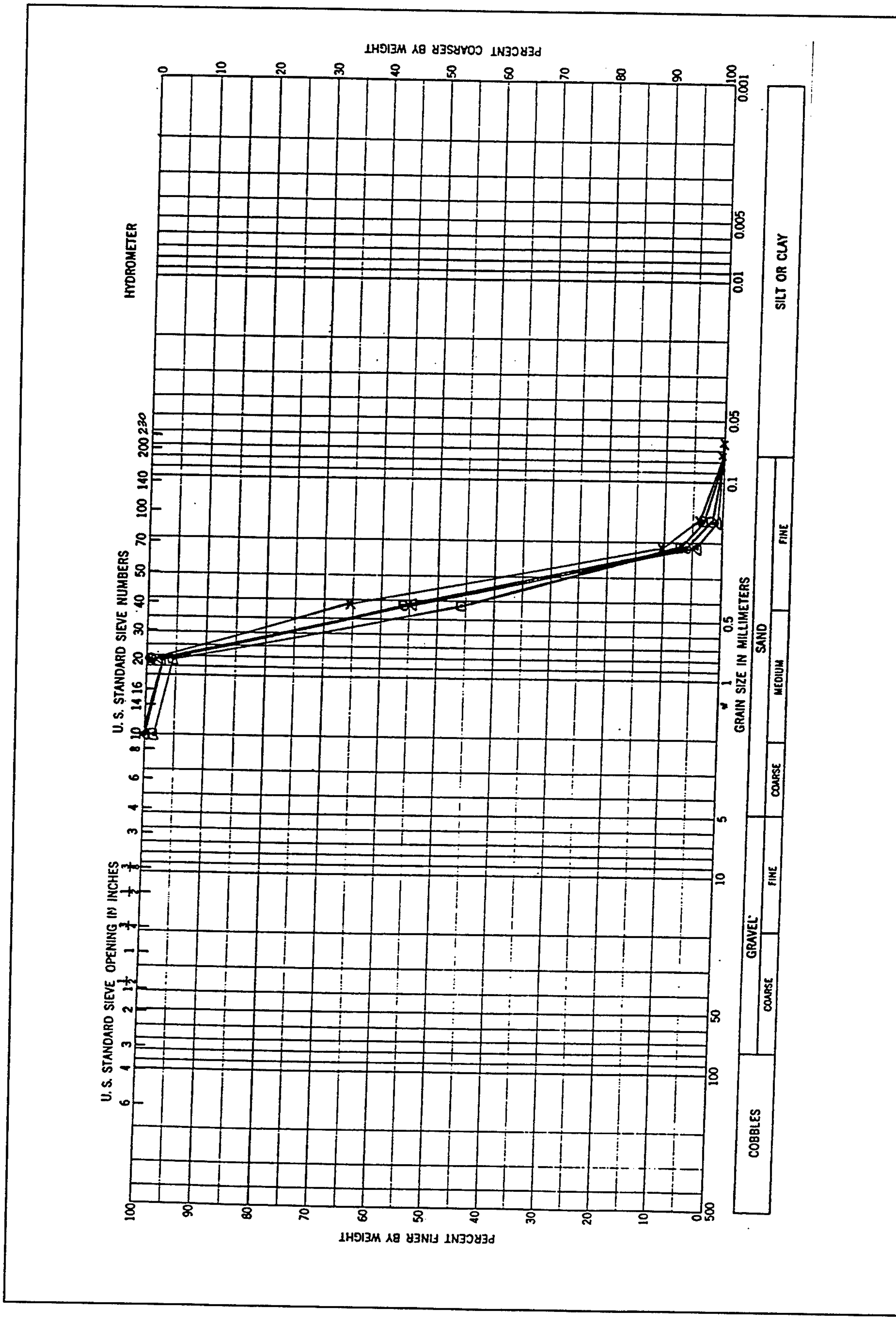

Figure 14. Size distribution of sand used for laboratory sediment mixtures

Table 1
Bulk Density of Kaolinite and Water Mixture

Sample Number	Kaolinite/Water Ratio	Bulk Density, g/cm³	Comment
1	1 : 1.25	1.376	Needs moderate squeezing to pour
2	1 : 3	1.181	Easy to pour
3	1 : 5	1.150	Easy to pour
4	1 : 6	1.123	Easy to pour
5	1 : 8	1.110	Easy to pour
6	1 : 10	1.061	Easy to pour
7	1 : 12	1.050	Easy to pour

Table 2
Bulk Density of Bentonite and Water Mixture

Sample Number	Bentonite/Water Ratio	Bulk Density, g/cm³	Comment
1	1 : 5	1.083	Needs squeezing to pour
2	1 : 6	1.052	Needs squeezing to pour
3	1 : 8	1.046	Needs squeezing to pour
4	1 : 10	1.037	Can be poured after shaking
5	1 : 12	1.023	Can be poured after shaking

Table 3
Matrix Showing Mixtures of Cohesive and Noncohesive Sediments and Water Prepared in Laboratory to Select Samples for Pump Testing

(B + K) / W = 1/3 B / K	Comment	(B + K + S) / W = 1/3 B / K / S %	Comment
5 : 1	Can be poured	75 : 15 : 10 (10 % sand)	Stiff mixture
3 :1	Needs moderate squeezing	64 : 21 : 15 (15 % sand)	Squeezable mixture
1 : 1	Squeezable paste consistency	40 : 40 : 20 (20 % sand)	Smooth mixture

Note: K = kaolinte, B = bentonite, W = water, S = sand.

4 Field Tests at WES

Introduction

The prototype dredge was tested under field conditions (Figures 15-32). Two operations were conducted, one at Vicksburg, MS, and the other at Louisville, KY. During the dredging operation, performance and production data were collected, and the effects on the surrounding environment were monitored. A videotape was prepared for technical and commercial distribution.

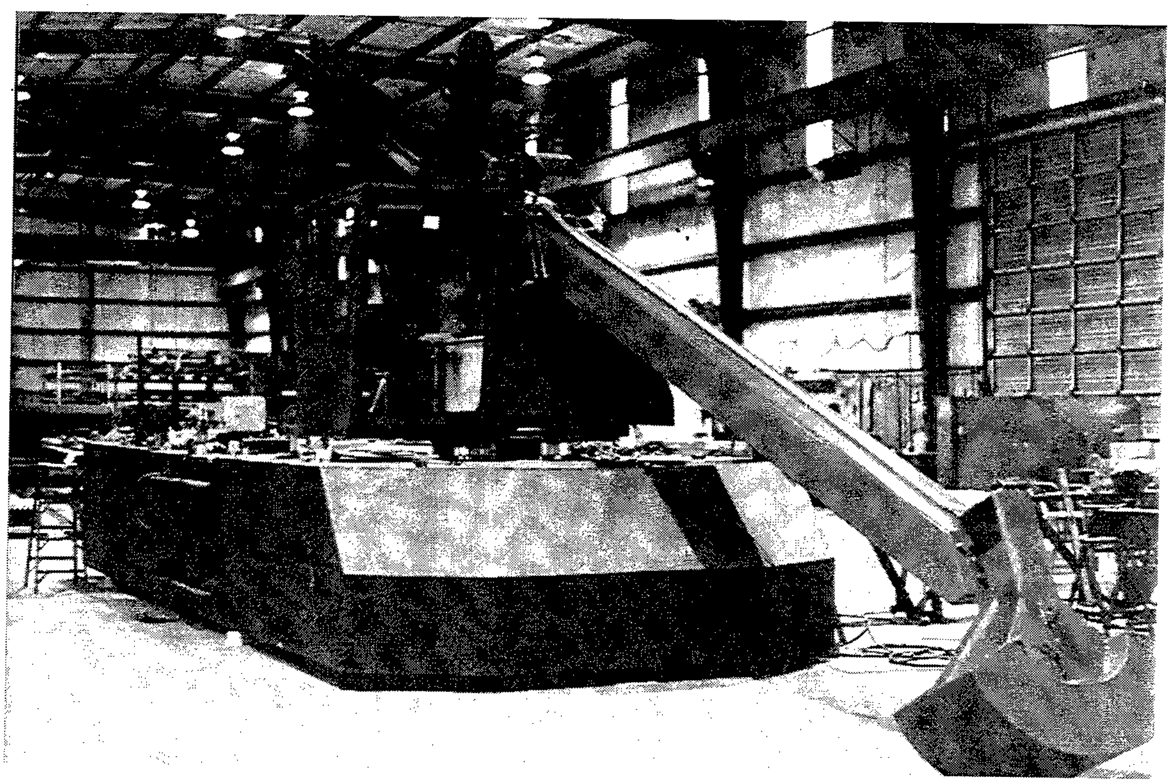

Figure 15. Dry DREdge™ in the fabrication shop

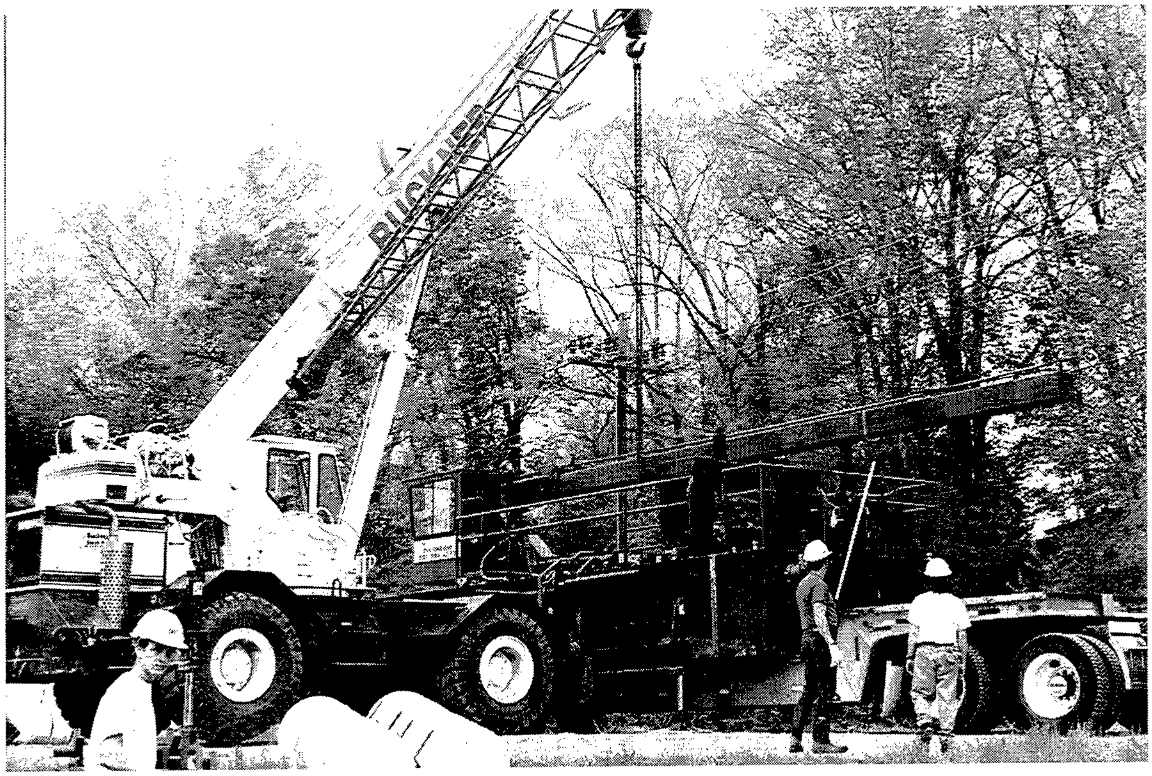

Figure 16. Dry DREdge™ mounted on trailer

Field Testing

The first field trial was conducted at Brown's Lake, a small man-made lake situated on the premises of the Waterways Experiment Station, Vicksburg, MS. The entire lake was relatively shallow, with depths varying from 0.3048 to 1.2192 m (1 to 4 ft). The shallowest parts of the lake were less than 1 ft deep, and the sediments consisted of mainly silt and clay. The site offered ideal conditions since the sediment deposits were not contaminated, the lake bed was not highly compacted, and the total volume of sediment to be removed was estimated to be only about 30,582 cu m (40,000 cu yd). The dredged material was to be deposited in a confined area which was located about 457 m (1,500 ft) away and 6.1 m (20 ft) above the lake level. A formal proposal for the work was received from DRE on 8 December 1995. Necessary paper work was completed, and a contract was awarded to DRE in April 1996. The work was expected to commence immediately in April 1996 and be completed within 16 weeks.

The dredger was transported by road to the Waterways Experiment Station on 18 April 1996. Initial dredging trials were taken by the end of April after assembling a 127-mm- (5-in.-) diam, 457-m- (1,500-ft-) long partly floating and partly land-based steel pipeline connecting the dredger to the dredged material disposal site. The area of the lake which was to be dredged was so shallow that a

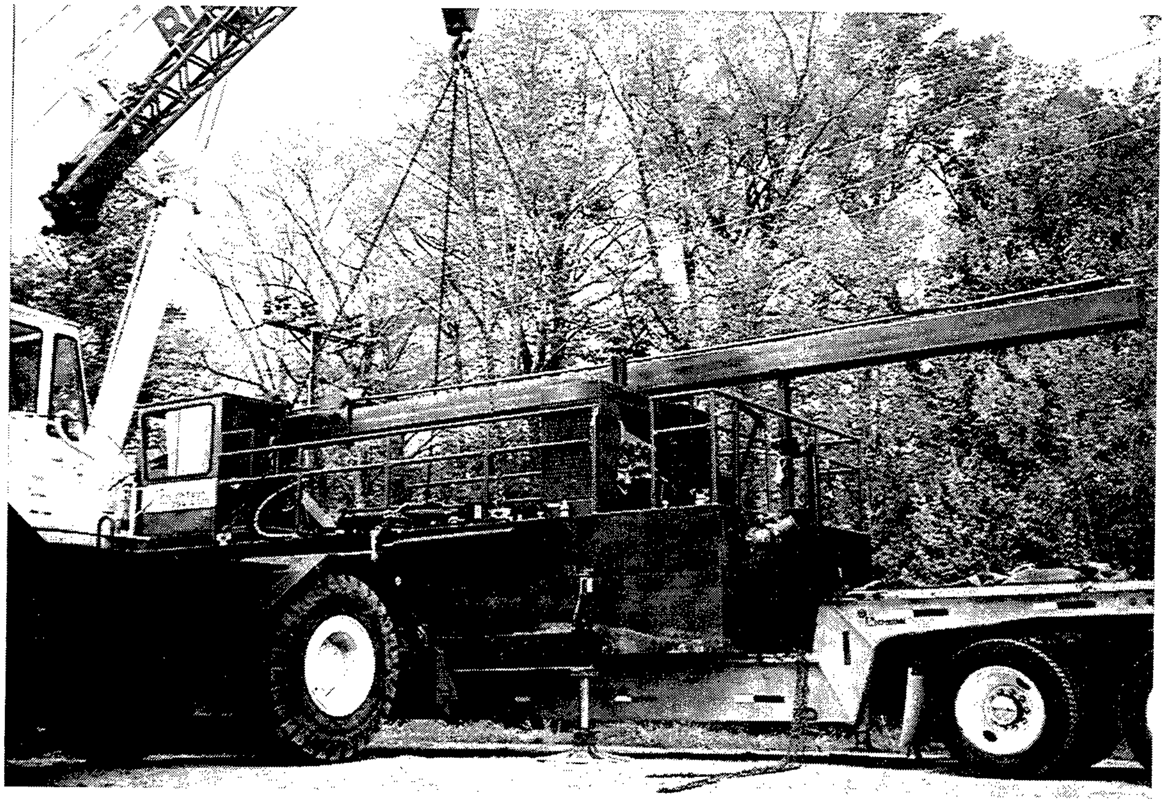

Figure 17. Crane used for lifting Dry DREdge™

channel had to be dredged with a backhoe for launching the dredger into the lake.

The operation of the dredger was monitored during dredging, and the rate of pumping was determined to be about 15 to 23 cu m (20 to 30 cu yd) per hour. Water samples at the point of dredging could not be collected for determining suspended sediment concentration because the water depth was less than 1 m (3.28 ft). Visual inspection indicated that the action of the clamshell during dredging did not significantly increase the suspended sediment concentration over any extended period of time.

Problems and Trouble Shooting

The first field trial proved to be a learning experience for DRE. Several problems were encountered during the trial phase as well as in the subsequent operation. DRE engineers and technicians spent considerable time, effort, and money in overcoming the problems that occurred during operation.

The following improvements were made to obtain a better performance of the dredge.

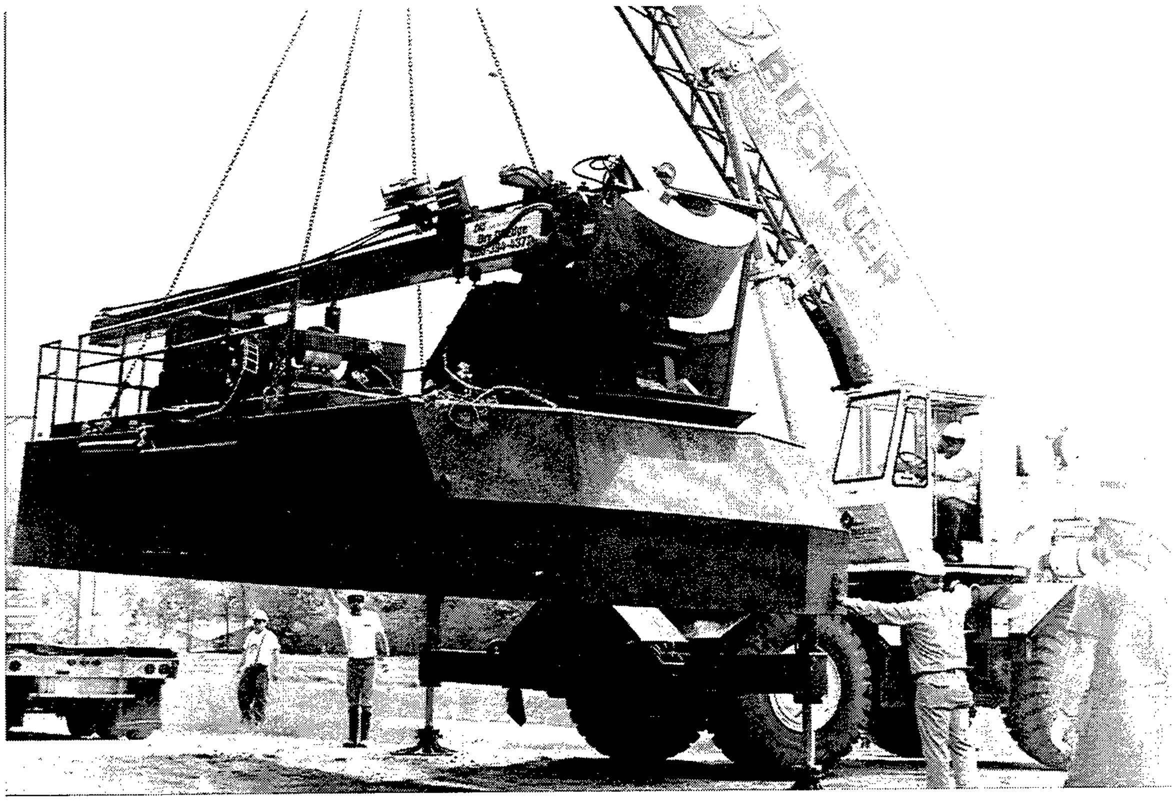

Figure 18. Dry DREdge™ being lifted by crane

a. A booster was added about halfway along the pipeline to increase the production rate and maintain a relatively lower pressure in the pipeline.

b. The flexible hoses used along the floating pipeline route were replaced by rigid pipes.

c. A custom-made long-radius 90-deg elbow was inserted to connect the floating pipeline to the shore-based pipeline.

d. Since it was found that the edges of pipes were wearing down rapidly within the victaulic couplings resulting in leakage, they were replaced by super-heavy-duty raised-flange couplings. These new couplings performed much better.

e. Dimensional misalignments were noticed between components of the main pump. It had to be taken to a local machine shop to get extensive realignment work done to enhance performance.

f. The flexible coupling between the pipeline and dredge was replaced by a pipe welded to the hull of the dredge.

g. Adjustments were made to the hydraulic system pressure, and a hydraulic accumulator was modified to relieve shock in the hydraulic system.

Figure 19. Transportation of Dry DREdge™ towards lake

Although some downtime was included in the estimate in anticipation of operational problems, considerable time was spent in identifying a variety of problems and rectifying them. Extra downtime also resulted due to heavy rains. Hence, the rate sediment removal from the lake was much less than anticipated. In order to meet the contractual obligations, DRE was granted time extension. In view of the time shortage for completing the job, DRE subcontracted a part of the dredging work to another company to operate their unit simultaneously and thus meet the deadline for completion of the project.

The dredging work at the WES lake was continued until August 1996. WES officials were invited to witness the field test. The performance of the dredge was not adequate in terms of the output rate; however, the first field test established the feasibility of using the dredger under field conditions.

Modifications to Dry DREdge™

The Dry DREdge™, which was demobilized from Vicksburg in August, was extensively overhauled and retrofitted at the DRE fabricators, Automated Equipment Inc., located in Paris, TN. More than 40 modifications were made based on the experience of its operation while dredging the lake at WES.

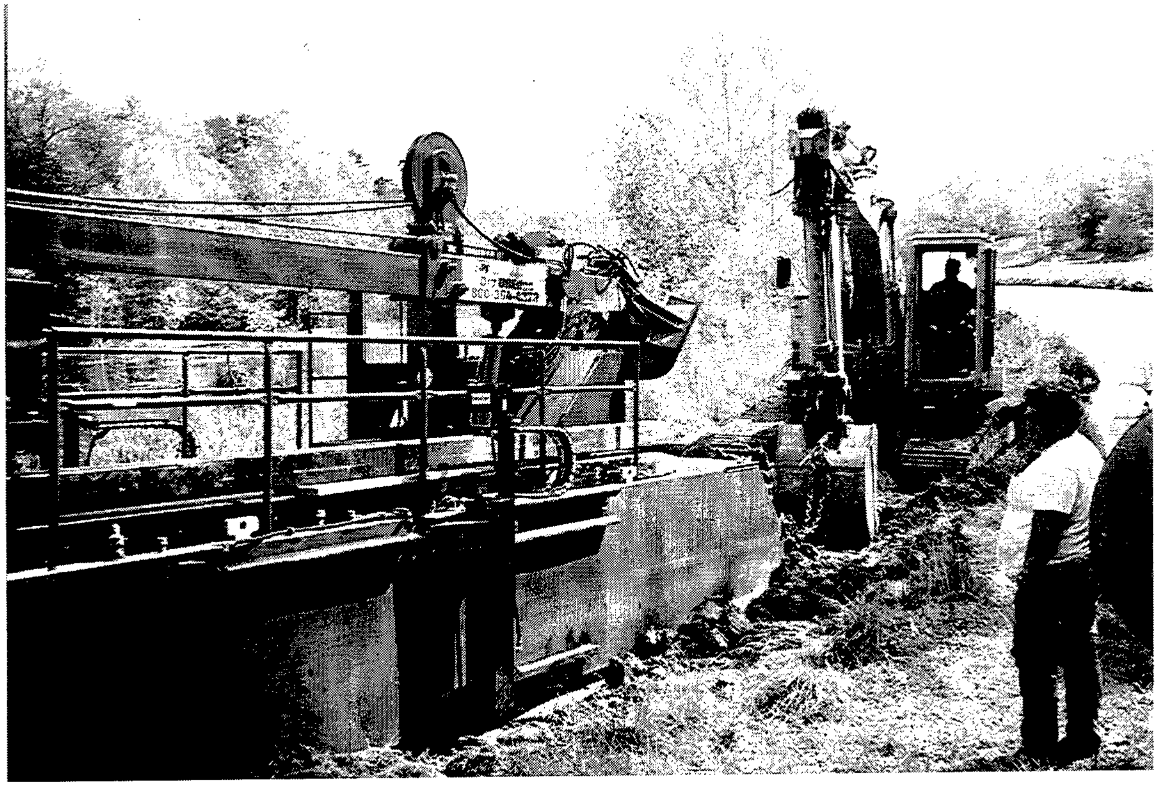

Figure 20. Dry DREdge™ being dragged towards lake

The major modifications included the following:

a. The main sediment pump was replaced by another manufacturer's model. This pump had a higher capacity of 45.8 to 61.1 cu m (60 to 80 cu yd) per hour, compared to the 23 to 30 cu m (30 to 54 cu yd) with the original pump.

b. The pipeline connections were changed to accommodate a 15.24-cm-(6-in.-) diam pipe.

c. Additional pipeline swivels were fabricated for greater pipeline flexibility.

d. A higher capacity hydraulic pump was installed to accelerate all boom functions.

e. Removable pontoon-type floats were added to the front of the dredge to increase stability.

f. Larger capacity hydraulic oil coolers were added.

Figure 21. Channel being dredged for launching

g. Deck hatches were modified for a more leakproof fit.

h. A 0.25-cu m (9-cu ft) capacity clamshell was to provided replace the previous 0.2-cu m (7-cu ft) size clamshell.

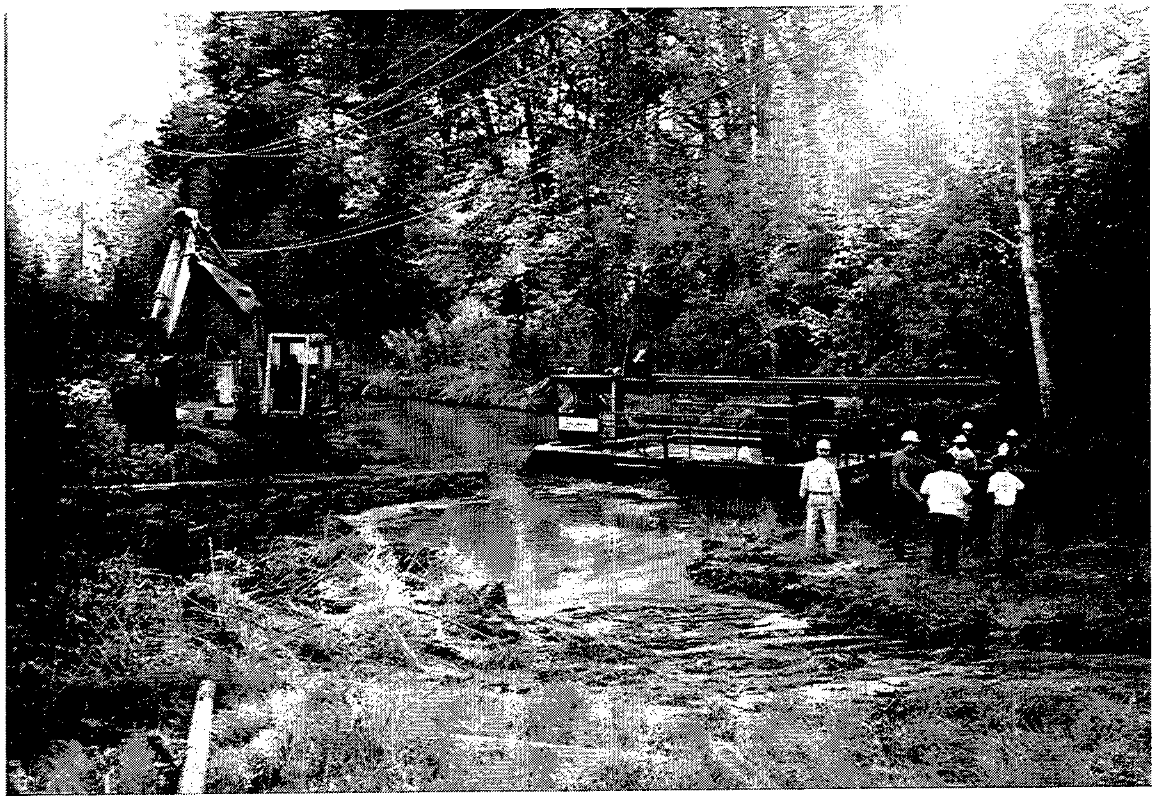

Figure 22. Dredge launched into the channel leading to lake

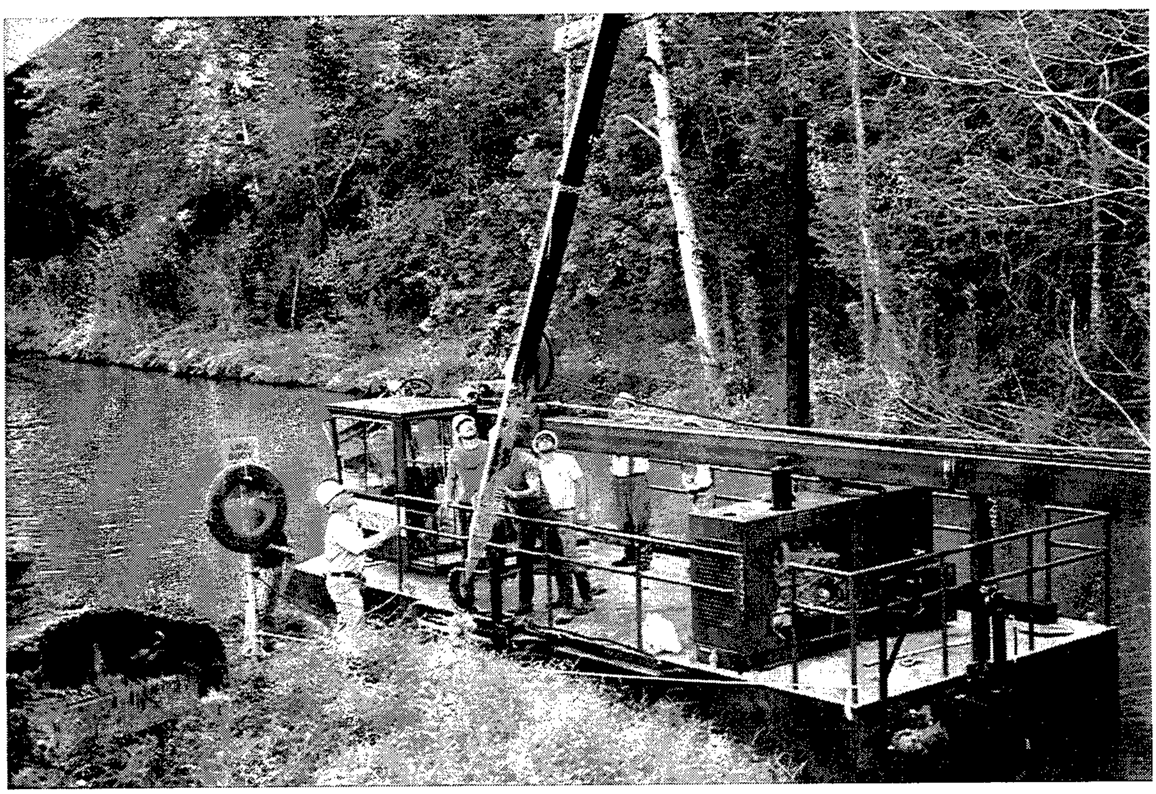

Figure 23. Right spud in position, left spud being lifted

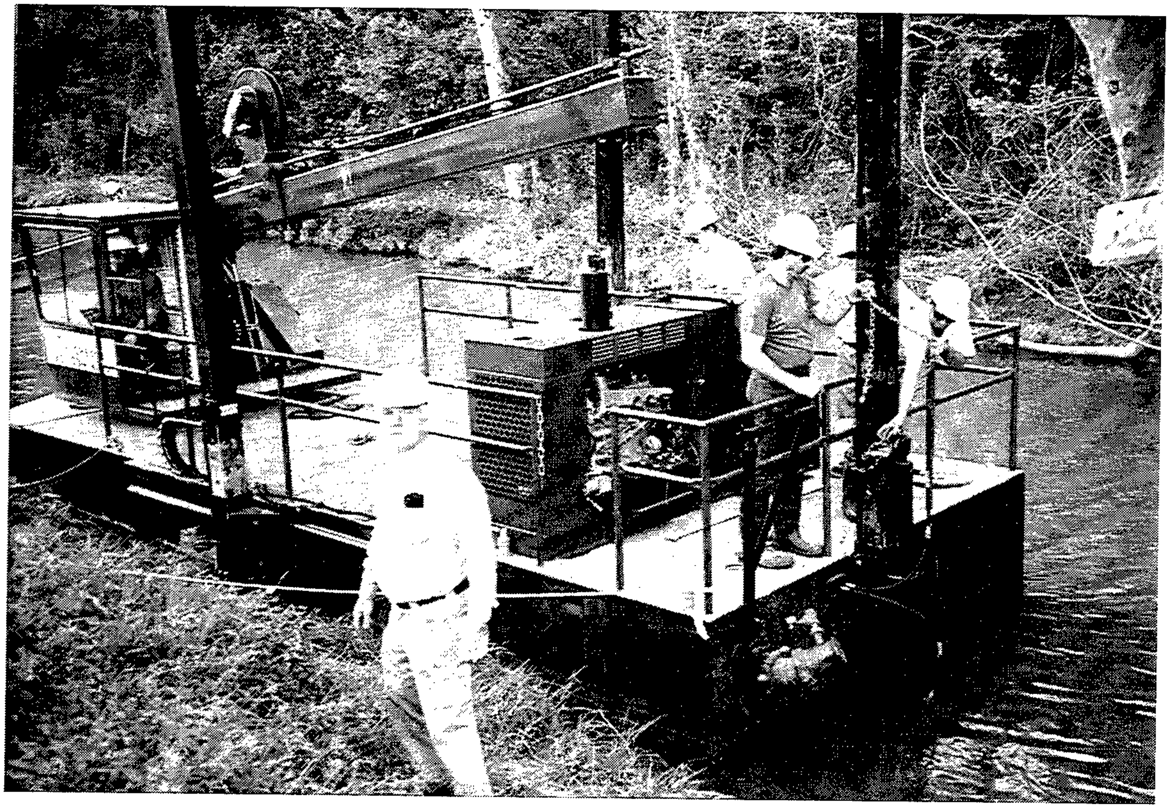

Figure 24. Right and left spuds in position, rear spud being placed into position

Figure 25. Dredge working in the lake

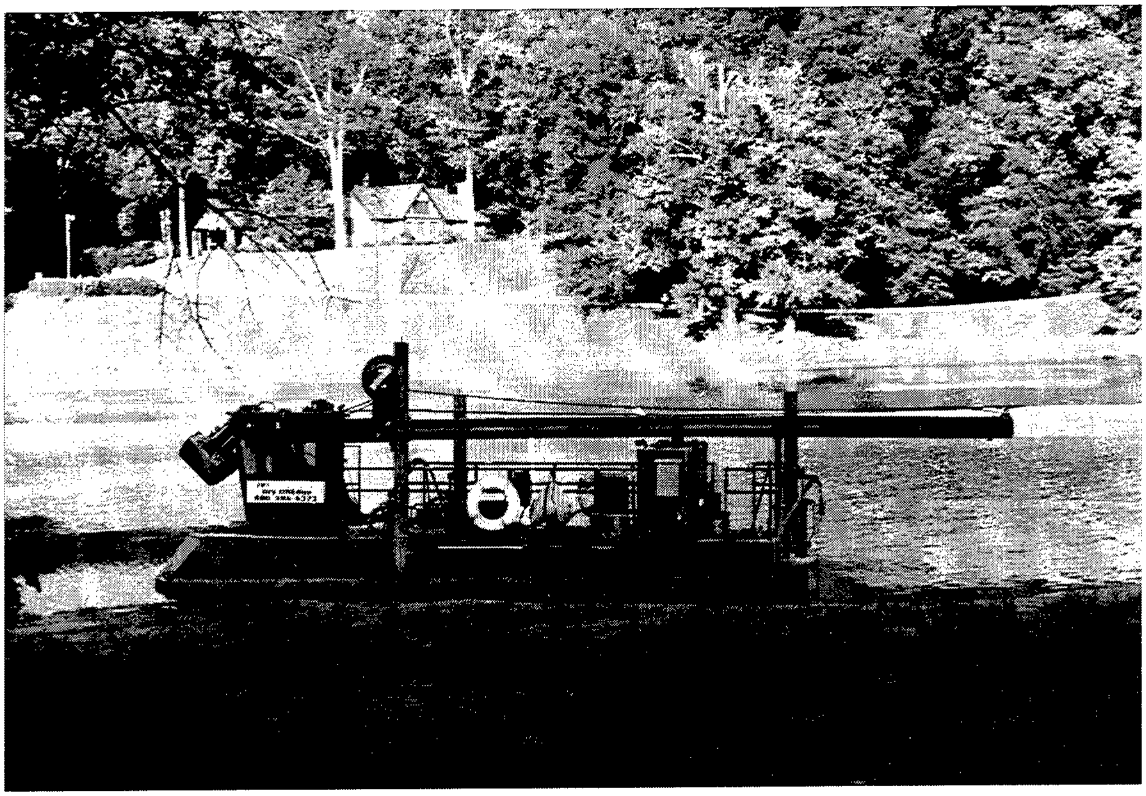

Figure 26. View of horizontal dredge arm

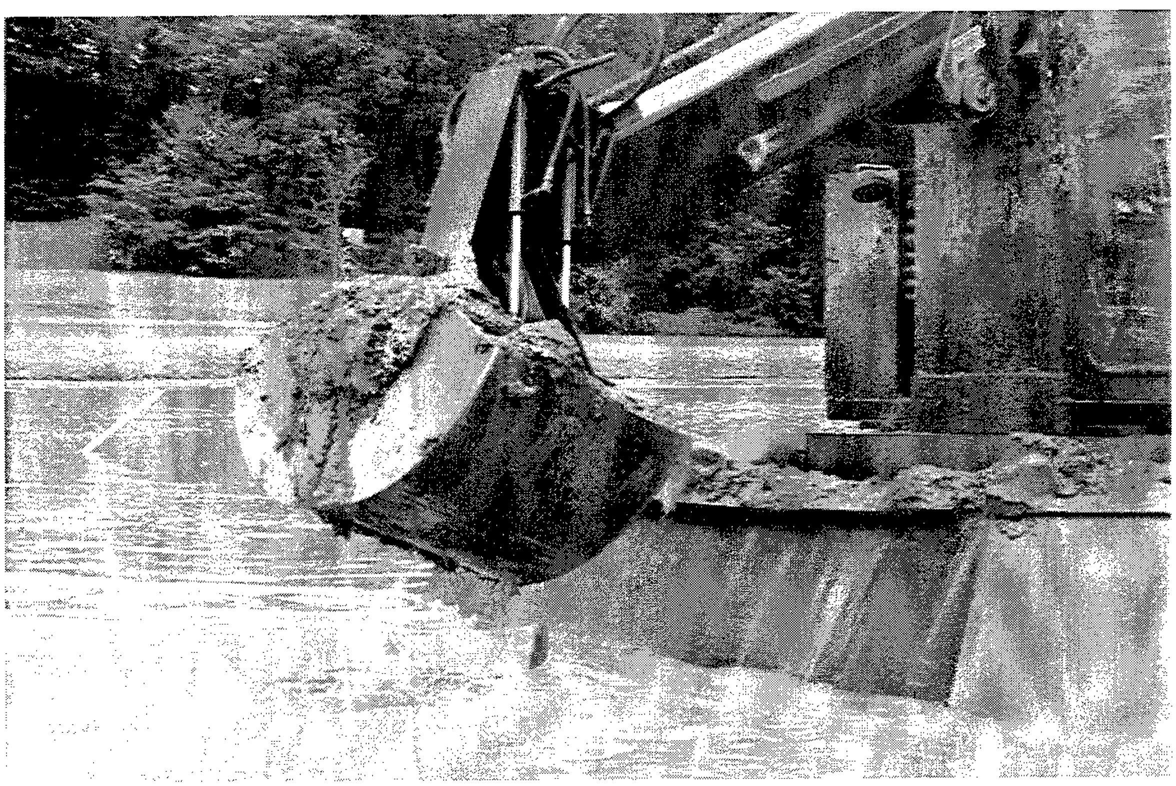

Figure 27. Bucket filled with sediment

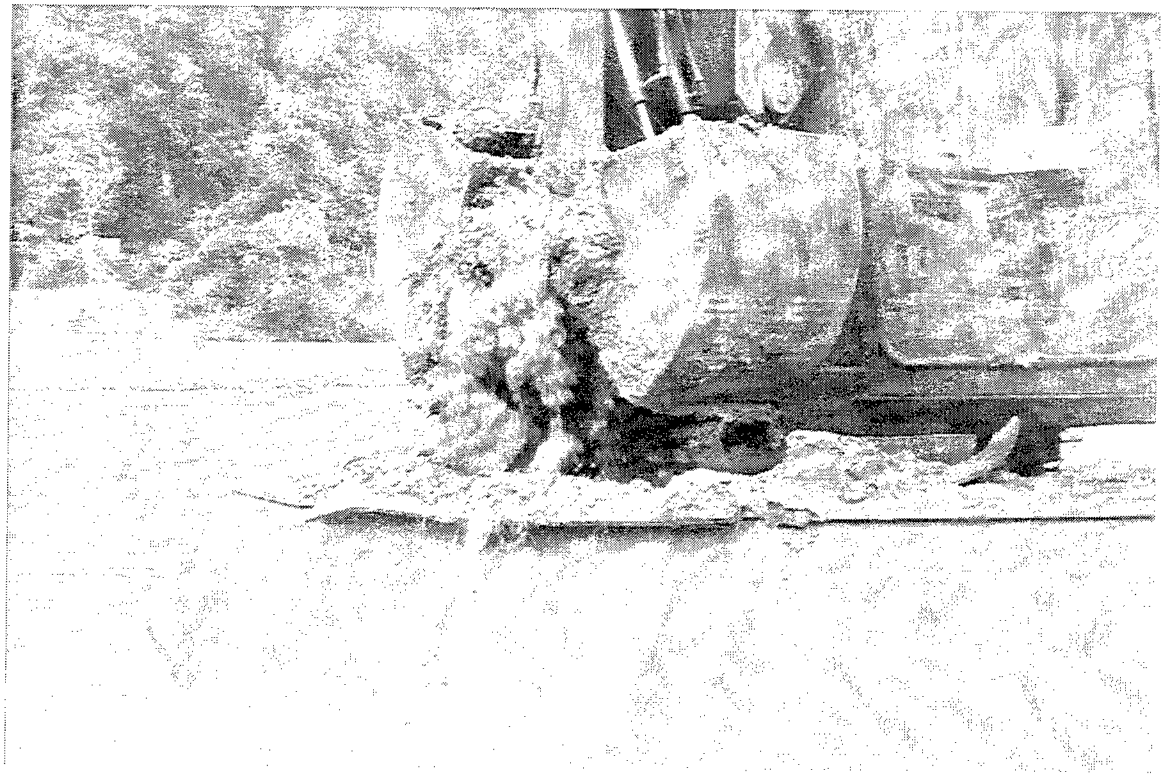

Figure 28. Bucket emptying into hopper

Figure 29. Booster pump halfway on the pipeline

Figure 30. Discharge of sediment at the disposal ground

Figure 31. View of sediment disposal site

Figure 32. View of disposal site after quick drying

5 Field Tests at Louisville, KY

Performance of Modified Dredge

The modified dredge was mobilized to an industrial site in Louisville, KY, to remove rubber emulsion solids from a nonhazardous wastewater treatment impoundment. The modified dredger worked much more satisfactorily than the original dredger at WES. The total quantity dredged was 12,997 cu m (17,000 cu yd).

The output of the dredger was measured using the "dumpster and stopwatch method" which consists of measuring the time required to fill a container of known volume. The results of measurements are given in Table 4.

Table 4
Dry DREdge™ Production Rate at Louisville, KY

Test Number	Date	Pumping Rate, cu m/hr (cu yd/hr)
1	09/17/96	21.40 (28.0)
2	09/17/96	18.96 (24.8)
3	09/17/96	22.93 (30.0)
4	Aborted	
5	09/20/96	27.37 (35.8)
6	09/20/96	24.08 (31.5)
7	09/20/96	26.98 (35.3)
8	09/20/96	26.30 (34.4)
9	10/96	22.63 (29.6)
10	11/96	27.37 (35.8)
11	12/96	30.58 (40.0)

6 Marketing and Technology Transfer

Marketing

DRE identified several ongoing remediation projects for which the Dry DREdge™ is suitable. Many of these projects were designed or administered by the Corps of Engineers and executed by private contractors. For CERCLA (Superfund) projects, the method of excavation is usually specified in the Record of Decision (ROD) or Remedial Action Plan (RAP), so it was essential that the marketing/education plan reach those individuals and organizations that prepare these documents. Based on the information provided by WES, DRE compiled a database of companies presently or likely to be working on contaminated sediment projects. DRE demonstrated and marketed the Dry DREdge™ throughout the industrial, environmental, and dredging markets. This marketing included mailings, telephone contacts, and presentations at the client's facilities.

A high-quality multicolor brochure (Appendix B) has been prepared by DRE for giving publicity to the dredge highlighting special features of the new machine. The appropriate title "Dry DREdge™" is expected to attract the attention of many potential clients.

Technology Transfer

WES provided technology transfer throughout the Corps of Engineers periodically by the use of Fact Sheets dated 3 January 1996 (Appendix C), 1 August 1996 (Appendix D), and 1 January 1997 (Appendix E). Copies of this Technical Report will also be sent according to the standard mailing list. The Partners (DRE and WES) will work together in reaching the U.S. Environmental Protection Agency (USEPA) and similar government authorities.

Efforts have been made to incorporate new procedures developed herein into existing Corps Guidance. The equipment and procedure are incorporated into existing training courses.

Additional Information

For more information on this project please contact:

Partner Principal Investigator: Mr. Robert J. McCormick
Vice President
DRE Technologies Inc.
137 Alpha Drive
Franklin, TN 37064
Tel: 615-591-0058
FAX: 615-591-8979

USACE - Lab Principal Investigator: Dr. T. M. Parchure
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199
Tel: 601-634-8459
FAX: 601-634-2823
e-mail: parchure@hl.wes.army.mil

7 Conclusions

The following conclusions can be drawn from this study:

a. The objective of this project was to design and build a commercial portable dredge capable of accurately removing and transferring subaqueous material at near in situ densities while minimizing the resuspension of contaminated solids. This objective was fulfilled through the development of Dry DREdge™.

b. The name Dry DREdge™ is appropriate in view of the low water content of the dredged sediment.

c. The dredge will be useful for the following operating conditions: shallow water depth (less than 4.5 m (15 ft)), small quantity of dredging, low output rate (less than 30.58 cu m (40 cu yd) per hour), sediment with a high proportion of fines and a low amount of sand, short pumping distance, no wave or current action.

d. This equipment is expected to allow the Corps of Engineers and others to remove contaminated material from our nation's waterways and from water bodies located on military reservations with minimal impact on the environment.

e. The dredging and disposal costs using the new technique are expected to be 40 to 70 percent lower than the presently employed conventional dredges.

f. The main advantage of the new system is the reduced overall volume of sediments and water to be handled and treated. In addition, the precise dredging this equipment allows for will be useful in closely following the predetermined limits of contaminated sediments and also in avoiding unexploded ordnance at certain sites.

g. The equipment is portable and small in size. Hence, it can be easily transported and deployed at small projects such as dredging of marinas and industrial lagoons where access near the piles and other structures inside basins is severely restricted.

h. The project progressed satisfactorily over the two-year period and was completed on time in spite of the numerous unforeseen problems encountered during the first field testing program. Necessary modifications were made subsequently, and the second field test was successful in terms of performance as well as the rate of output.

i. The Dry DREdge™ holds promise to be valuable for dredging not only contaminated sediments, but also most forms of organic/fine sediments and several types of industrial waste products.

j. The marketing approach of DRE seems to be effective, and the company already has offers to deploy the Dry DREdge™ for removing sediment from a marina and wastes from industrial ponds.

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Appendix A CPAR Executive Summary, FY 95

1. **TITLE**: Development of a Portable Innovative Contaminated Sediment Dredge

2. **INDUSTRY AND LABORATORY PARTNERS:**

DRE Technologies Inc.	U.S. Army Corps of Engineers
Suite 420	Waterways Experiment Station
111 Westwood Place	3909 Halls Ferry Road
Brentwood, TN 37207	Vicksburg, MS 39180-6199

3. **OBJECTIVE:** Develop and demonstrate a new concept for dredging contaminated sediments. The product will be a commercially available portable dredge capable of accurately removing and transferring subaqueous material at near in situ densities while minimizing resuspension of contaminated solids.

4. **APPROACH:** The work is envisaged in three phases. Phase 1 and 2, lasting 8 months, will be executed by DRE with WES consultation. In phase 3, lasting 16 months, the dredge will be deployed by DRE and its operation monitored and evaluated by WES.
Phase 1: Establish that a piston type pump is capable of pumping dredged sediment at near in situ moisture content. This concept is not new, but has not yet been proven when deployed on a dredge in a field environment.
Phase 2: Detailed design and construction of the dredge will be accomplished. The design includes a sealed clamshell mounted on a rigid telescopic boom. This configuration provides accurate control of the clamshell location and in situ hydraulic closure to ensure complete filling of clamshell. These features reduce resuspension of bed sediment normally associated with the impact of a free-falling cable-suspended clamshell.
Phase 3: Testing of the dredge at two field dredging sites will be done. During the tests, changes in the suspended sediment concentration of ambient water will be measured and data related to operation, production rate, and performance of the dredge will be collected and analyzed. The accuracy and precision of the

dredge will be evaluated as relates to removing material in rigidly prescribed areas. Tech transfer activities will report the findings.

5. POTENTIAL IMPACT ON U.S. CONSTRUCTION INDUSTRY PRODUCTIVITY:
The new dredge will provide the construction industry with an improved capability for removing contaminated sediments. In contaminated material, savings should range from $15 to $50 per yard of material removed. Precision dredging will be possible with the new portable dredge, increasing productivity by allowing the efficient dredging of docks, wharves, marinas, and other restricted areas that are beyond the mission area of the Corps.

6. POTENTIAL IMPACT ON CORPS OF ENGINEERS:
The cost of removing, transporting, and disposing this material ranges from $50 to $250, depending on the site conditions. The new dredge should reduce the volume of contaminated material handled by a factor of 3, with commensurate savings, particularly in handling and disposal. The dredge will add an important capability for the clean up of military installations and will allow the Corps to remove contaminated material from our nation's waterways with minimal impact to the environment.

7. COMMERCIALIZATION AND TECHNOLOGY TRANSFER POTENTIAL:
DRE will produce and market the dredge through the industrial, environmental, and dredging markets. Marketing will include mailing, telephone contacts, and presentations at the client's facilities. WES will provide technology transfer throughout the Corps of Engineers by providing presentations, technical reports, technical notes, and publishing articles in bulletins and journals. Procedures and technology developed through new research will be incorporated into existing Corps Guidance and training courses.

8. EASE OF ADOPTION: The new dredge will be designed as a general purpose piece of equipment readily available in the market. The dredge will be capable of being transported by road without major disassembly. Extensive special training will not be needed for its operation.

9. ANTICIPATED CHANCE OF SUCCESS OF R&D EFFORT:
The design employs technologies well-proven in other industries. The primary task in the development of this dredge is the integration of these technologies into a dredge. The proposal has been extensively peer reviewed for feasibility. Based on WES technical expertise and DRE industrial capabilities, confidence is high that this research effort will be completely successful.

10. PROJECT DURATION: The project will be executed in 3 phases as outlined in section 4 above, and will be completed in two years.

11. R & D INVESTMENT: This project will cost $875,000 to the DRE and $675,000 to the COE over a two year period as indicated below. No Corps funds will be used by DRE.

Partner	Year 1	Year 2	Total
DRE	$ 750,000	$125,000	$ 875,000
Corps	$ 330,000	$345,000	$ 675,000
Total	$1,080,000	$470,000	$1,550,000

Appendix B
DRE Brochure on Dry DREdge™

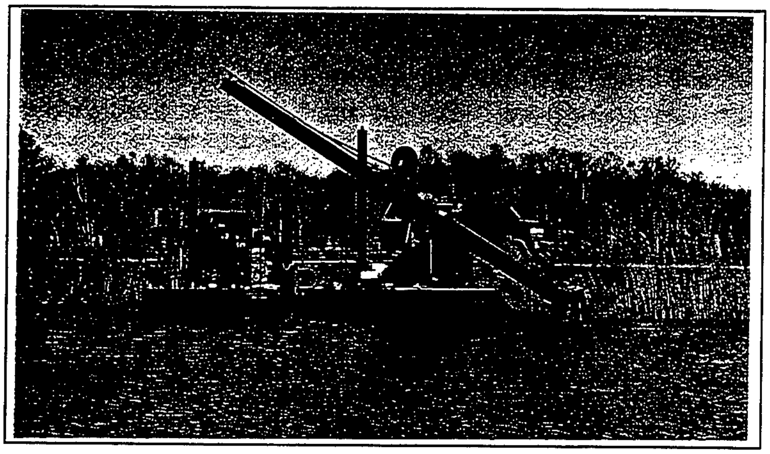
Dry DREdge™

Specialty Dredging Technology from *DRE technologies, inc.*

Description

DRE's interest in dredging technology began in the early 1990's. The company was seeking an economical and environmentally acceptable method to excavate, dewater, and feed contaminated sediments to treatment systems at remedial action sites. The conventional excavation methods — hydraulic dredging and mechanical dredging with clamshells or draglines — suffer from several serious limitations. These limitations include significant resuspension of sediments at the point of excavation, imprecise excavation of "hot spots", and free water entrainment in sediments requiring expensive dewatering and return water treatment.

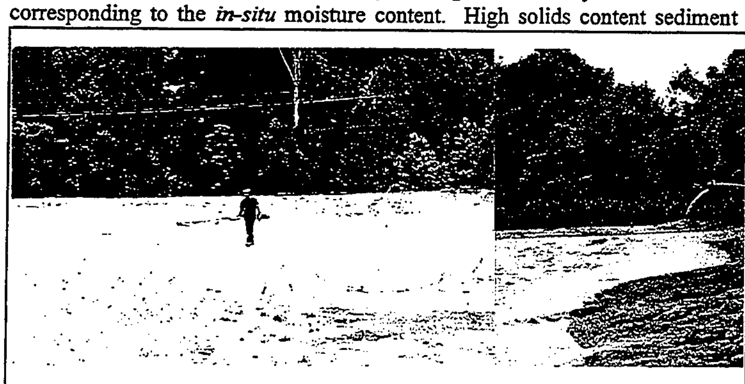
The Dry DREdge technology was developed to avoid these limitations while retaining the most desirable features of conventional hydraulic and mechanical dredging. The Dry DREdge (U.S. Patent No. 5,311,682) incorporates a specially-designed, sealed clamshell mounted on a rigid, extensible boom. The open clamshell is hydraulically-driven into the sediments at low speed, minimizing sediment disturbance and resuspension. The clamshell is then hydraulically closed and sealed, excavating a plug of sediment at its *in-situ* content.



The sediment is deposited in the hopper of a positive displacement pump. Depending on the application, the hopper can be equipped for debris screening, size reduction, vapor emission control, sediment homogenization, and blending of additives to modify flow properties. The sediment is pumped in a plastic flow regime through a pipeline to its appropriate disposition. The discharge has the consistency of toothpaste. Depending on the in-situ moisture content and degree of hazard posed by the sediment, the disposition may be direct feed to a thermal treatment or stabilization process, direct feed to on-site land disposal, or direct feed to an enclosed transport vehicle.

Advantages

The most unique advantage of the Dry DREdge is its ability to deliver sediments at **high solids concentration** corresponding to the *in-situ* moisture content. High solids content sediment delivery can offer major economic advantages through the reduction or elimination of dewatering and return water treatment. Solids concentrations up to 70% have been pumped by the Dry DREdge.



Excavation is **accurate and precise** with the Dry DREdge. The azimuth, declination, and extension of the clamshell is electronically displayed in the operator's cabin and available for electronic input to a programmable controller. Therefore, the extent of the excavation (length, width and depth) is easily controlled by the operator. The programmable controller can be configured to completely excavate the area within range of the dredge by systematically making a grab, depositing the material in the pump hopper, and returning to make another grab immediately adjacent to, or overlapping, the last grab.

The clamshell-boom configuration allows the Dry DREdge to work around rocks and pilings. It is not limited to rectangular excavation patterns as are horizontal auger dredges, or the inverted cone excavation patterns of rotating basket dredges. The Dry DREdge excavation capabilities are ideal for "hot spot" remediation.

Excavation is achieved with **minimal resuspension** of sediments. Hydraulic dredge cutter heads agitate the sediments in the vicinity of the pump suction. Conventional clamshells are allowed to free-fall in order to impact the bottom with enough force to penetrate. Draglines are pulled randomly through the sediments. All these operations disturb the surrounding sediments, resuspending particles and contaminants. Resuspension is a major concern when dredging is conducted in bodies of flowing water such as estuaries.

The Dry DREdge is intrinsically sound for **debris management**. Unlike hydraulic dredges, the pump suction is above surface allowing visual inspection of debris by the operator. Debris can be removed or shredded and pumped. The decision-making capability is critical for certain types of debris — unexploded ordnance, for example.

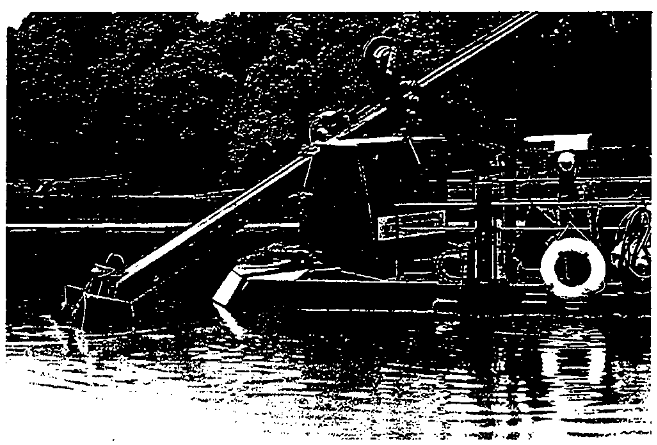
U.S. Army Corps of Engineers CPAR Program

The United States Army Corps of Engineers (USACE) recognized the many challenges facing conventional dredge technology when dealing with contaminated sediments and established the Construction Productivity Advancement Research (CPAR) Program. Recognizing the potential of the Dry DREdge to meet many of these challenges, the USACE awarded a CPAR matching funds contract to DRE in February 1995. The program consisted of four phases: proof-of-concept testing, prototype design, prototype construction, and prototype demonstration.

A commercial-scale demonstration of the Dry DREdge was conducted in mid-1996 at the Waterways Experiment Station in Vicksburg, Mississippi. Excavating lake sediments, the Dry DREdge produced a discharge stream containing approximately 70% solids, 1.7 specific gravity, and less than 5% free water.

Applications

The Dry DREdge is the economical choice for many applications in the areas of industrial wastewater impoundment maintenance, dock and marina maintenance, contaminated sediment removal from harbors, and other environmental remediation. The inherent advantages of the Dry DREdge — high solids delivery, elimination of return water handling, precise excavation, minimal resuspension, and effective debris management — offers significant cost savings in many such applications.



For more information please call or write:

DRE technologies, inc.

111 Westwood Place
Suite 420
Brentwood, TN 37027
615/373-1373 373-3107 fax

3838 N. Sam Houston Parkway
Suite 540
Houston, TX 77032
713/442-0373 713/442-1769 fax

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Appendix C
Fact Sheet Dated 3 January 1996

US Army Corps of Engineers

Construction Productivity Advancement Research (CPAR)

Fact Sheet

Directorate of Research and Development
Attn: CERD-C
20 Massachusetts Avenue, N.W.
Washington D.C. 20314-1000
(P) 202-272-0257

A Corps/Industry Partnership to Advance Construction Productivity and Reduce Costs

Fact Sheet CP - 22-
January 3, 1996

TITLE : Development of a Portable Innovative Contaminated Sediment Dredge

TECHNOLOGY CHALLENGE : Contaminated sediments consist of fine sticky clays and often require incineration. The cost of temporary storage and incineration of sediment substantially increases with increasing water content. The existing technology of hydraulic transport using centrifugal pump requires mixing large amount of water with sediment for ease of pumping. Large savings could be achieved if sediments are removed and transported at *in-situ* water content.

DESCRIPTION OF PROJECT : The objective of this project is to design and manufacture a portable dredge which can be used for removal of contaminated sediment from shallow waters without changing their *in-situ* water content either during removal or transport. The new technique involves use of a special clamshell for removal of sediment from the bed and a piston-type pump for transporting the sediment through a pipeline. Sophisticated instrumentation is provided for accurate positioning of the clamshell and the dredge.

STATUS OF PROJECT : The new dredge has been given a Trade Mark name "Dry Dredge" for marketing. A patent has been obtained on the feeding of a positive displacement pump with a clamshell mounted on a rigid arm. Laboratory tests were successfully conducted at WES on the piston-type pump for transporting sediment at a very low water content. The dredge design is complete and the fabrication of a prototype is underway. The dredge is expected to be ready for field trial by late February 1996.

PARTNERING Corps Laboratory : Waterways Experiment Station, Vicksburg, MS
Industry Partner: DRE Technologies, Inc., Brentwood, TN

COST SHARING Corps Share : $ 675,000 Industry Partner Share : $ 855,000

POINT OF CONTACT

Industry : Charles N. Sturdivant, P.E.
Principal Engineer, DRE
Suite 420, 111 Westwood Place
Brentwood, TN, 37027
Tel : 615-373-1373

Corps : Dr. T. M. Parchure
Research Hydraulic Engineer, WES
3909 Halls Ferry Road,
Vicksburg, MS, 3918
Tel : 601 - 634 - 3213

Appendix D
Fact Sheet Dated 1 August 1996

Construction Productivity Advancement Research (CPAR)

US Army Corps of Engineers

Fact Sheet

Directorate of Research and Development
Attn: CERD-C
20 Massachusetts Avenue, N.W.
Washington D.C. 20314-1000
(P) 202-272-0257

A Corps/Industry Partnership to Advance Construction Productivity and Reduce Costs

Fact Sheet CP - 22
August 1, 1996

TITLE : Development of a Portable Innovative Contaminated Sediment Dredge

TECHNOLOGY CHALLENGE : Contaminated sediments consist of fine sticky clays and often require treatment such as dewatering, stabilization, or incineration prior to disposal. The cost of temporary storage and treatment of sediment substantially increases with increasing water content. The existing technology of hydraulic transport using centrifugal pump requires mixing large amount of water with sediment for ease of pumping. Large savings could be achieved if sediments are removed and transported at *in-situ* water content.

DESCRIPTION OF PROJECT : The objective of this project is to design, manufacture and demonstrate a portable dredge which can be used for removal of contaminated sediment from shallow waters without changing their *in-situ* water content either during removal or transport. The new technique involves use of a special clamshell for removal of sediment from the bed and a piston-type pump for transporting the sediment through a pipeline. Sophisticated instrumentation is provided for accurate positioning of the clamshell and the dredge.

STATUS OF PROJECT : The new dredge has been given a Trade Mark name "Dry DREdge"™ for marketing. A patent has been obtained on the feeding of a positive displacement pump with a clamshell mounted on a rigid arm. Laboratory tests were successfully conducted at WES on the piston-type pump for transporting sediment at a very low water content. The dredge design and fabrication of a prototype are complete. The dredge is currently undergoing field trial at Waterways Experiment Station.

PARTNERING Corps Laboratory : Waterways Experiment Station, Vicksburg, MS
Industry Partner: DRE Technologies, Inc., Brentwood, TN

COST SHARING Corps Share : $ 675,000 Industry Partner Share : $ 855,000

POINT OF CONTACT

Industry : Robert J. McCormick
Vice President
DRE Technologies, Inc.
Suite 420, 111 Westwood Place
Brentwood, TN, 37027
Tel : 615-373-1373

Corps : Dr. T. M. Parchure
Research Hydraulic Engineer
Waterways Experiment Station
3909 Halls Ferry Road,
Vicksburg, MS, 39180
Tel : 601 - 634 - 3213

Appendix E
Fact Sheet Dated 1 January 1997

US Army Corps of Engineers

Construction Productivity Advancement Research (CPAR)

Fact Sheet

Directorate of Research and Development
Attn: CERD-C
20 Massachusetts Avenue, N.W.
Washington D.C. 20314-1000
(P) 202-272-0257

A Corps/Industry Partnership to Advance Construction Productivity and Reduce Costs

Fact Sheet CP - 22
January 1, 1997

TITLE : Development of a Portable Innovative Contaminated Sediment Dredge

TECHNOLOGY CHALLENGE : Contaminated sediments consist of fine sticky clays and often require treatment such as dewatering, stabilization, or incineration prior to disposal. The cost of temporary storage and treatment of sediment substantially increases with increasing water content. The existing technology of hydraulic transport using centrifugal pump requires mixing large amount of water with sediment for ease of pumping. Large savings can be achieved if sediments are removed and transported at *in-situ* water content.

DESCRIPTION OF PROJECT : The objective of this project was to design, manufacture and demonstrate a portable dredge to be used for removal of sediment from shallow waters without changing the *in-situ* water content either during removal or transport. The new technique involves use of a special clamshell for removal of sediment from the bed and a piston-type pump for transporting the sediment through a pipeline. Sophisticated instrumentation is provided for accurate positioning of the clamshell and the dredge.

STATUS OF PROJECT : The new dredge has been patented and given a Trade Mark name "Dry DREdge"™. Laboratory tests were successfully conducted at WES on the piston-type pump for transporting sediment at a very low water content. The dredge design and fabrication of a prototype are complete. The dredge has undergone field testing at Waterways Experiment Station and is now in commercial operation.

PARTNERING Corps Laboratory : Waterways Experiment Station, Vicksburg, MS
Industry Partner: DRE Technologies, Inc., Brentwood, TN

COST SHARING Corps Share : $ 675,000 Industry Partner Share : $ 855,000

POINT OF CONTACT

Industry :	Robert J. McCormick	Corps :	Dr. T. M. Parchure
	Vice President		Research Hydraulic Engineer
	DRE Technologies, Inc.		Waterways Experiment Station
	137 Alpha Drive		3909 Halls Ferry Road,
	Franklin, TN, 37064		Vicksburg, MS, 39180
	Tel : 615 - 591 - 0058		Tel : 601 - 634 - 3213

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Trimbak M. Parchure, Charles N. Sturdivant

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DRE Technologies, 137 Alpha Drive, Franklin, TN 37064

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13. ABSTRACT *(Maximum 200 words)*

The Construction Productivity Advancement Research (CPAR) Program allows the U.S. Army Corps of Engineers (USACE) to enter into cooperative research and development agreement with construction industry partners to conduct cost-shared, collaborative effort with the goal of improving construction productivity. The Cooperative Research and Development Agreement (CRDA) document was signed by WES and DRE Technologies Inc. to undertake development of a portable innovative contaminated sediment dredge. An amount of $675,000 was received from the Government under CPAR Program and DRE Technologies Inc. contributed $855,000 for the project.

The research work was conducted by personnel of DRE Technologies Inc. and the Coastal and Hydraulics Laboratory of the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, during 1995-1996. Three major problems are associated with dredging of contaminated sediments: (1) The contaminated sediment are mostly fine and highly compacted, and specialized devices are needed for cutting and loosening them before transporting, (2) the dredged fine sediments are vertically resuspended and dispersed easily within the entire water column and adversely affect the aquatic plants and water quality, and (3) the sediments have a very low rate of deposition, and they may be transported over great distances from the point of origin even under a very weak current. Laboratory tests were conducted at WES in which different mixtures of clays,

(Continued)

14. SUBJECT TERMS
Cohesive sediment dredging
Contaminated sediment dredging
Dredging equipment
Dry DREdge™
Innovative dredge
Positive displacement dredge

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sand, and water were pumped through a pipe, and pressure in the pipe was measured. The effectiveness of a positive displacement pump for pumping sediments with a very low water content was established, and the extent of the addition of clays and water for improving the relative ease of pumping was determined. The dredge was then used in a field trial for removing bottom sediments from a lake at WES. The new dredge, named the Dry DREdge™, removes sediments at near in situ water content with the use of a clamshell bucket. The sediments are placed in a hopper and are pumped by a positive displacement pump to the required disposal site.